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A RIGID EARTH.

GEOLOGY

As Applied to Mining.

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A RIGID EARTH

BEING DEVOTED TO

GEOLOGY AS APPLIED TO MINING.

EMBRACING A REVIEW OF ACCEPTED THEORIES.

BY

STEPHEN BARTON.

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PREFACE.

In treating of geology as applied to mining the author has been prompted by the hope of contributing aid in arresting a class of mining exploration which have generally ended in disaster to the miner and which he believes will continue to do so. If ore bodies bear any relation to a melted interior other than as a part of the earth, that fact remains to be proven, notwithstanding the fidelity the miners of the Pacific Slope have shown as disciples of the igneous theory. Let the reader draw a picture of the energy exhausted, the hopes blighted, the millions squandered, in a vain effort to connect the source of rich deposits with the effects of fusion.

Reared amid the busy appliances of a mining community, a half century of close observation in the mines of New Jersey, Wisconsin, and California, has served to convince the author that heat was not an agent in the formation of ore bodies; and only in instances, and in slight degree, an effect. The suggestion is therefore presented that the theory of a melted interior has no foundation in scientific truth; that there is no loss of heat—either by the earth, the spheres, or the system, and that the universe itself reposes on a stable structure.

AUTHORITIES REFERRED TO.

CHARLES LYELL, author of "Elements of Geology;" James D. Dana, author of "Manuel of Geology;" "Whitney's Geology of California;" J. Ross Browne, author of "Resources of the States and Territories of the Pacific;" "Whitney's Metallic Wealth of the United States;" Bradley A. Fisher on Electricity; A. Ure, "Arts, Mechanics, and Mines;" Overman on the Reduction of Silver Ores; Pitkenton on Mechanics; Jackson on Minerals and Fossils; Dawson and Logan on Archian Formations; Sir Humphrey Davy on the Radiation of Heat; Berzelius, Ingenhousz, Pictet, and Caletet as authorities on Chemistry.

CONTENTS.

law of compensation governs continents and oceans; and from such a standpoint to deduce the rule that the depth of the smaller ocean is proportioned to the width of the larger.

One great fact all leading geologists notice while they leave it unexplained. And that fact is, that the continents are all grouped in one hemisphere. They do not seem even to notice that nearly all the elevated mountain ranges of the world stand nearly upon the periphery of these hemispheres. This last fact would be an awkward one to explain in connection with the theory of the fluid condition of the earth's interior. On the contrary the location of these mountain ranges goes far to prove the rigidity of the earth, since their combined weight subjects its frame-work to a thousand times the strain produced by the forces represented in the tides. Is there not then a possibility that the earth is a rigid mass?

Let us examine the question, and at the same time inquire into the means by which the two hemispheres are balanced. The South Pacific, though broad, is believed to be very shallow. Directly on the other side of the earth is the North Atlantic, which, though narrow, presents the deepest soundings yet revealed to science.

On the theory of a rigid earth the mountain ranges may be assumed to go far toward balancing each other. It now remains to balance deep seas and low table-lands against a broad, shallow ocean with Australia in its center.

Continent Making.

When the grandest mountain chain referred to in the recorded history of the earth's structure, and located on the southern margin of Hudson's Bay, was being ground down by the southerly flow of the oft-recurring ice-continent, much of the matter was carried to the southeast by the general slope of the surface, and deposited in the Atlantic forming the banks of Newfoundland. The deep trough of the Atlantic being thus filled at that point, the course of the tropical current was turned from the polar sea, where, according to geological data, its modifying influences had previously been felt. Hence, that region is no longer susceptible of producing those forms of vegetation found imbedded in the coal-measures of the frigid zone.

One of the strongest arguments in favor of the existence of a former high temperature of the earth is this same evidence of a former mild climate in high latitudes. If, as we have already suggested, glacial action cut off the deep-sea connection between the Atlantic and the frozen ocean with a powerful warm current setting in that direction, it may be that the ice-continent, which, subsequently with each precessional revolution of the equinoxes, must have spread out over all lands and shallow waters of high latitudes, had not yet invaded the polar sea. The evidence seems to be that glacial action, or at least the southern flow of ice over the American continent, was in greatest force during the Tertiary and Quartinary Periods. It may be urged that large bowlders and heavy granite blocks are not known to have been transported in any other period than that of the Quartinary. To this it may be answered, however, that the flow of sedimentary matter from the north, though possibly without

bowlders, was in such quantities from the earliest Silurian down to the Tertiary as to utterly confound the reasoner as to the source of supply. To assume that a continent was built of the ruins of a single mountain range, is to assume that the time was when lofty mountain ranges produced more inequalities of pressure on the earth's crust than has been sustained in more recent periods. This would be reasoning in the wrong direction to prove the former fluidity of the earth. But the depth of sedimentary formations on the margins of seas is what Mr. Dana has most relied on to prove the crushing in or folding together of sedimentary formations in the groin of the continent. To this it may be answered that great depths of sedimentary matter are what may be expected at points where mud-bearing currents encounter deep, still water.

During the Champlain Period the sea was at a higher level in the northern part of North America than it is at the present. Without stopping to inquire into the effect of chemical agencies in changing the level of lands and continents, it may be suggested that this change of level may have been due to causes already noticed.

The transporting of a continent to the southward would to that extent change the center of gravity of the earth, and cause the whole solid frame-work of the earth to push itself northward through the fluid elements to the extent of balancing the matter transported to the south. While an ice-continent occupied the whole of the frigid zone it would have the effect to depress the land for the time, and bring an equal amount of the fluid matter toward that pole of the earth, while the melting of the ice would disperse that amount of fluid all over the earth, and would thus raise the land at the pole.

So far as is known the Archian includes the Azoic. In other words, sedimentary rocks merge into the oldest crystalline formations. The carboniferous era, so called, is more carboniferous in some regions than in others, but as to whether it is more carboniferous than other eras is still debatable. Lime, alumina, silex and soda are pretty evenly divided between the Archian and the Tertiary.

The leading champions of the igneous theory are forced to admit that the coal-measures include all kinds of sedimentary rocks, such as shale, sandstone, millstone-grit, limestone, etc., etc. Mr. Dana admits that the rocks of the coal-measure must be told by their fossils and not by their composition.

Immense veins of iron ore are found in Archian formations; and these veins have been regarded by some geologists as the chief repository of the metal, but when we reflect that much of the solidifying influences, even in alluvial deposits, is due to the heavy impregnation of iron, we are almost forced to conclude that continents being built up are composed of the same percentages of material as those being torn down. If the theory of a carboniferous era cannot be sustained, then the age of steam vanishes.

Let us reflect, for one moment, what would be the result if the earth was a fluid mass and the continents all grouped in one hemisphere. That the one hemisphere exactly balances the other is too self-evident and too well established by the laws of astronomy to admit of question. Now, let us suppose that enough lead rested upon the floor of the Southern Pacific to balance the continents. Would it not crush through the thin crust of the earth and sink to the center? In such a case the continents would be submerged.

Now, suppose that this terrible strain acted upon the thin crust of the earth at the time of the earthquake of Lisbon, when the whole earth was shaken from center to circumference, and when, according to Mr. Lyell, ships cruising in the South Pacific experienced a shock as if they had struck a rock. With a fluid earth such a shock must have sunk either the continents or the heavy matter which balances them. The amount of curvature on the earth's surface by which the arc of the crust must be sustained, if the earth is fluid, is about eight inches on a mile.

A wave of vibration exceeding this would break this arc, and let the continents fall in. But if it is answered that it is buoyant, and floats on the melted matter, then we come again to the same difficulty encountered in the start.

But we must not credit the advocates of the igneous

theory with any violent assumption. A just statement of the theory would probably be that a modicum of the weight of the ocean-bed is represented by folding along the margins of the continents, while, for the most part, the continents and the whole earth's crust are sustained by buoyancy.

There are several objections to this theory of the cooling process:—

1st. If the continents' and earth's crust are merely congealed portions of the matter of a molten sea, then the fact of cooling should add ponderosity instead of buoyancy, and the continents should sink.

2d. Admitting the buoyancy to stand as a fact, though unexplained, then the earth's crust is the thickest where the greatest amount of buoyancy is required, viz., under the continent. Therefore, the folding should be in the deepest trough of the ocean instead of along the margins of the continents.

A paradox is encountered, however, when we come to the proposition that the bed of the ocean is sinking by this same cooling process of the interior. If the interior of the earth is shrinking to the extent of producing the mountains, by folding, then the sinking of that portion of the crust which is several miles the thinest cannot be, except the ponderosity of the crust is greater than the melted matter, and the strain would have a tendency to break the arc, and cave inward the bed of deep seas. In the latter case it is clear that the machinery of the world is run on a most precarious plan, and the sinking of the ocean bed may at any time break the curve of the arc, and let the heavy matter settle to the bottom, and the melted matter spread over the surface.

If the ocean is growing deeper, there is an increase in the amount of water on the face of the earth. This extra supply of water could hardly have been drawn from the atmosphere, for these reasons:—

1. The whole atmosphere, if condensed to the specific gravity of water, would only represent thirty-three feet and four inches of water over the entire earth, or, say fifty feet over the surface of the ocean; and thus the fossils of the car-

boniferous epochs must have subsisted under a pressure of twenty atmospheres, which their structure is not claimed to prove.

2. The advocates of the igneous theory have the visible supply of oxygen (one of the constituent elements of both air and water) constantly drawn upon in the oxidizing of melted matter while cooling. If we accept this igneous theory, we must conclude that hydrogen has been disengaged from its combination with oxygen in the form of water, and that owing to its levity it must form an upper stratum to our atmosphere, and that the depth of this stratum must increase in proportion as the supply of oxygen is absorbed by the solid earth. With the loss of oxygen the supply of water must diminish. If the oxygen, entering the solid earth, is drawn from the air, then that fact would account for a loss, which as yet has not been detected, without leaving any chance for the conversion of air into water to increase the depth of the ocean.

The convenience of this mode of reasoning will suggest itself to the ordinary mind if it can be shown that both high mountains and deep seas are produced by a mere shrinkage of the earth's crust. The evidence is that the retiring of the ocean from former sea-levels is much the greater in the region of the poles. Now, astronomy teaches that the length of the day has not varied more than one three-hundredth part of a second since the time of the first recorded eclipse, about two thousand years ago, and, therefore, if there has been a shrinkage of the earth there has been a loss of diurnal velocity and centrifugal force in almost exactly the same ratio. This of itself would be a strange coincidence. But when we consider that this loss of centrifugal force would tend to allow the ocean to retire, to some extent, towards the flattened region of the poles, we see the logic is at fault. The observed facts point the other way.

The fluctuations of coast lines are not explained by the theory of cooling. It will hardly be claimed by the advocates of the folding process that the same force unfolds it again, and yet there are numerous evidences of these fluctua-

tions of sea-level having acted both ways during the historic period. There have been very great fluctuations of the west coast of South America within the last three hundred years; but there is one notable case mentioned in every standard work on geology of the present age, which may be cited as an index to a rule; and in doing so I will quote Mr. Dana, for he seems to be the leading champion of the igneous theory, and the facts set forth by him will be accepted as data by all. He says:—

"The temple of Jupiter Serapis, at Puzznoli, was originally one hundred and thirty-four feet long by one hundred and fifteen feet wide, and the roof was supported by fifty-six columns, each forty-two feet high and five feet in diameter. Three of these columns are now standing; they bear evidence, however, that they were once, for a considerable time, submerged to half their height. The lower twelve feet is smooth; for nine feet above this they are penetrated by lithodomous, or boring shells, and remains of the shells (a species now living in the Mediterranean), were found in the holes. The columns, when submerged, were consequently buried in the mud of the bottom for twelve feet, and were then surrounded by water nine feet deep. The pavement of the temple is submerged. Five feet below it there is a second pavement, proving that these oscillations had gone on before the temple was deserted by the Romans. It has been recently stated, that for some time previous to 1845, a slow sinking had been going on, and that since then there has been a gradual rising." (It is proper to state that this Puzznoli is in Southern Italy.)

There are reasoners who claim that the bed of the ocean is sinking from the weight of the mud and silt which is accumulating in certain regions. If the earth's crust is thin enough to yield to such a force, then what is it that sustains the mountains and continents above the level of the sea? Such an argument needs no reply.

Attention has already been drawn to the manner in which the solid frame-work of the earth behaves while the fluid ocean is being drawn from one hemisphere to the other with

the attraction of an ice-continent on the pole; or, perhaps, more properly, the manner in which the solid frame-work of the earth is shoved through the fluids by the *weight* of an ice-continent on the pole. But in view of the fact that some writers dwell upon the weight of submerged mud-flats in the bed of the ocean, it may be proper to give this subject a more careful examination.

Whether it is the attraction of the ice-continent on distant fluids, or its weight on solids in proximity, are only different ways of stating the same thing. The distant fluids and the distant solids are both attracted in proportion to their weight; but only the fluid moves because the solids are held in position by the weight of the attracting force, which rests upon the opposite end of the solid earth.

Certainly it will be claimed that the ice-continent is a thing of slow growth, and that very little strain is encountered by the frame-work of the earth at one time; and it may be claimed that when the movement has once taken place the strain ceases. This last portion of this claim cannot be allowed. Suppose that the transfer of water to the Southern Hemisphere raised mountain peaks ten miles above the level of the sea on the shores of the Arctic Ocean. This certainly would subject the frame-work of the earth to a terrible strain. Then again when the mud-flats, formed in the ocean by the melting of the ice at the North, were laid bare by the retiring of the water, and the North American continent was lifted from one thousand to several thousand feet above the level of the sea, there certainly would be a greater strain here than there was when the ocean soundings were more than a mile deep over most of the continent.

A tidal wave representing more than five miles in depth at the pole would be as certain in its effect as it was slow in its movements; and yet the proof of the existence of a rigid earth is the sequel of its effects.

Mr. Dana admits that the South Pacific is only twelve thousand eight hundred feet deep, while soundings have been taken north of the Bermudas, in the North Atlantic, twenty-five thousand five hundred feet deep.

The continents are but an insignificant portion of the earth's surface. The imaginary line dividing the continental hemisphere from the oceanic hemisphere, passes over the highest part of South America, leaving most of the Andes on the oceanic side. It runs parallel with, and in close proximity to, the Rocky Mountains, and then bending southward along the coast of Japan, runs nearly parallel with the Himalayas in Asia, and the Mountains of the Moon in Africa. If we deduct from the calculation these elevated areas, which on the theory of a rigid earth would balance each other, we shall find that a shoaling of the broad expanse of the Southern Pacific by three thousand or four thousand feet over the depth of other seas, would fully balance the low table-lands in the center of the continental hemisphere. Thus while treating the Antarctic continent as an unknown factor we see that the earth is apparently very little out of balance.

It has been urged by some that the flattening of the earth at the poles proves its fluidity. To assume that the earth should have been a true sphere would have just as much warrant as to assume that this was the original purpose of nature as relating to the shape of grapes or eggs.

The whole universe revolves around a common center, and this movement is the parent of all minor rotation. Matter descending from a larger orbit to a lesser one, is accelerated in its movement by the descent, and at the same time attracts interior matter away from the center of motion, thereby causing it to lose velocity. Therefore:—

Matter coming from points exterior to an orbit strikes the outside of the nebula in a direction oblique to its course, and communicates rotation in proportion to relative bulk and lessening of orbit.

Hence diurnal rotation and a flattened pole is a part of the law governing the aggregation and growth of nebulous matter, and proves nothing so far as it relates to a fluid condition of the earth.

This simple reason enables us to discern the following law:—

Planets with a broad sphere of attraction are remarkable for

great diurnal velocity, and hence for the elevation of their equators, and for the depression of their poles.

By thus harmonizing sciences we may gain an insight into the laws governing the whole universe,—

The depression of the earth's poles is geometrically proportioned to the earth's sphere of attraction in the nebular hypothesis, and is from its primitive structure.

Facts are stubborn things, and if it can be shown that the expansive force of rock in quarries is parallel with the axis of the mountain chain, and at right angles with coast lines, it would seem to silence the theory that there is a constant crushing force exerted from the direction of the sea.

Prof. W. H. Niles observed such an effect in the gneiss quarries of Monson, Massachusétts. One mass, three hundred and fifty-four feet long, eleven feet wide, and three feet thick, expanded an inch and a half in a northerly and southerly direction after being released from the quarry. In the absence of any evidence of expanding east and west we are entitled to infer that the expanding force had found vent in the direction of least lateral pressure, or toward the sea. We certainly are entitled to infer that there was no crushing force exerted from the direction of the sea, else the expansion had been greatest in that direction when the pressure was removed. This we understand to be a universal law of statics and dynamics. How any scientist could use such a fact as evidence that there was a crushing force exerted from the sea seems past comprehension.

Igneous Theory.

THE theory of a rigid earth encounters one difficulty, however, which can only be overcome by the complete overthrow of the accepted philosophy respecting the radiation of heat. If heat radiates into space the earth and sun are both cooling off. Admit this proposition and the mind is carried back to the time when the earth's surface glowed with the most intense fusion, like that is supposed to be which enables the sun to send its benign influences through the solar system. Once establish this theory and it becomes apparent that eternity itself must perish.

The French philosophy respecting the existence of the substance called caloric was overthrown by Sir Humphrey Davy, by generating heat by rubbing two pieces of ice together. The French theory gave us a rather reasonable explanation of the condition of the change when the different elements of water are separated. It could be claimed that the liberated hydrogen absorbed several thousand times its own bulk of caloric from adjacent space or matter, and produced that intense coldness so observable in the presence of chemical action producing such a result. There are many questions in science which can only be solved on the theory that there is such a substance as caloric. On the other hand the facts observable in Sir Humphrey Davy's experiments might perhaps be explained in another way. If we should conclude that friction changed the prime equivalent ratio by which caloric combines with other substances, it would seem to offer just as reasonable an explanation of observed phenomena as the one accepted.

So far as we use the present as a key to reveal the past we are able to make the world unfold to us its own history.

Waves lashed the shores of the Silurian sea as they do of the seas of to-day. But when we go beyond the Archian we find our geologists entering a sea of speculation as to an era of fusion, while there is really no evidence to show but what the oldest known rocks are sedimentary.

The theory of fusion has been applied to the production of veins bearing metallic ores. That there are dykes of erupted matter traversing various formations cannot be questioned for one moment, and that metallic deposits have in some cases formed by the side of these dykes will readily be admitted. But to assume that sulphide of lead is in some cases injected into the fissure by eruption, and from the top in another, seems absurd; and the more particularly since lead in a fluid form is not known to have existed on the surface of the earth. The discovery of silver ore among the sand and gravel beds of Colorado has nearly upset this theory, and if cubes of galena are found in the same formation the igneous theory as applied to metallic veins will doubtless be abandoned. Galena has long since been found in a fissure having the bearing of the magnetic pole, and running through a horizontal formation, with an unbroken formation of other varieties of rock above and below, through which the fissure did not penetrate, showing that the galena did not come either from above or below. Other evidences, such as bones imbedded in galena, have shown that galena occurring in the fissures of rocks of the Lower Silurian Age had been deposited during the Tertiary Period, or after the existence of mammals of the present type. All this occurs in horizontal formations which show no trace of volcanic action, and in places where communication with the fissure is shut off by solid formations above and below, through which no fissure runs, and where the only approach to such fissure is from the bluff of a ravine which cuts down through the formation. Facts equally conclusive have been known to intelligent miners for a third of a century. The evidence, therefore, is that heat was not an agent in the formation of mineral veins, for having demonstrated that in numerous cases the galena was formed under present condi-

tions, we are entitled to conclude that all galenas were formed under similar conditions. We are entitled to go further, and conclude that all mineral veins of the character of those bearing galena were formed in the same way.

Veins have been divided into several classes by geologists: as true fissures, ribbon veins, gash veins, etc., etc., depending mainly upon size and extent. A true fissure has been supposed, however, to grow wider as it enters the earth. This theory of increase is necessary to the theory of the volcanic origin of true fissures. A true fissure has therefore been supposed to increase in size to a depth far beyond the reach of practical explorations. It has cost the miners of the Pacific States hundreds of millions of dollars to explode this theory. It is astonishing how disciples of the igneous theory, as relating to formation of metal-bearing veins, should cling to an accepted dogma in the face of observed facts. Still more astonishing is the manner in which they will attempt to reconcile those facts with the accepted theory.

J. Ross Brown, in his work entitled "Resources of the States and Territories of the Pacific," in speaking of the Mother Lode, which runs from the town of Mariposa to the town of Amador, almost continuous, except that river gorges more than two thousand feet deep cut below it, says: "Streams seem to have made their beds where the Mother Lode is split up into a number of branches, as at the Merced, Tuolumne, Stanislaus, and Mokelumne Rivers, and Maxwell's Creek, while in those places where the lode is wide and solid there are high hills."

If he had said that the lead is wide and solid where the hills are highest he would not have been conveying an absurd inference. Whoever will explore the towering peaks, the overhanging precipices, and yawning chasms of the Sierra Nevada Mountains and will then glance down among the lower foot-hills and say the Mother Lode had anything whatever to do in giving character to the landscape, will be only making himself appear insane to anyone acquainted with the geography of the western slope of those mountains. It is an exception to a general rule that a metal-bearing vein

resists the action of time and the elements, better than the country rock. The exceptions on the Mother Lode are at Tuttletown and Carson Hill. Even in the few places where veins stand out in bold relief, as at the two places named, the configuration of the country leads to the conclusion that the denuding forces were accelerated in their action on the walls of the vein by the sulphur and acid gases generated and escaping from the vein itself. Professor Whitney is more cautious in regard to the ultimate depth of what are called true fissure veins. In his "Metallic Wealth of the United States," he says: "True fissure veins are continuous in depth and their metalliferous contents have not been found to have been exhausted or to have been sensibly or permanently decreased at any depth which has yet been obtained in mining."

The observed facts lead us to suppose that scarcely a metal-bearing lode in the known world reaches to the depth of one mile. The Mother Lode is nowhere more than three thousand feet deep, and it is doubtful whether any trace of the Comstock will be found four thousand feet deep. The increase in the size of a lode with depth only shows the extent of decomposition and decay near the surface. When a lode is mined out, the walls invariably spring in and the fissure becomes narrower. The same result follows when the vein is partially decomposed by the action of the elements; but low down in the earth, beyond the action of these forces, all fissures grow narrower with depth. Of course the veins here referred to are the metal-bearing veins. Mr. Dana, in his "Manual of Geology" (page 109), says: "Veins are divided in dykes and proper veins."

The evidence points to origins and forces so widely different that it would seem that dykes and veins might each have been considered under separate heads; but it is probable the learned professor wrote that sentence before he heard of deposits of lead and silver among the gravel beds of Colorado.

It is now becoming a recognized fact that the temperature of the walls of the Comstock decreases in geometrical ratio

with the square of the distance to which they may be penetrated horizontally at right angles to the trend of the lode. Thus it is proved to a demonstration that the excessive heat encountered by the miners is generated within the walls of the vein. The sulphurets are converted into sulphates and oxides by the action of air and water, while at the same time heat and sulphuric acid gas are evolved.

This reasoning from effect to cause adopted, as we have seen, by J. Ross Brown and others, would credit the quartz lodes with determining the course of the rivers and the whole configuration of the landscape; and all this in order to sustain the theory of the eruptive origin of metallic veins. On the other hand, if we read the facts as they are, we shall find that in every gorge three thousand feet deep there is no Mother Lode, and that no tunnel piercing the river bluffs at that level has ever reached the lode.

Much theorizing has been indulged in as to the prospect of finding a depth in the Comstock at which the vein would be found to follow a vertical rent in the older rock of the foot wall instead of following the seam between that and the metamorphic rock above. This theorizing was sufficient to keep the great Savage pump running for years after the various explorations thus rendered possible had penetrated the earth below the realm of profitable mining. The millions upon millions of dollars thus expended in fruitless search were not entirely thrown away however; for they have aided to establish what might reasonably have been inferred before, viz.: That metal-bearing lodes are formed by forces acting near the surface of the earth, and that it is the existence of a fissure and not the question of its origin which determines the position of a lode. Metal-bearing lodes, then, are formed in fissures. These fissures may mark a rent caused by volcanic action. They may occupy the dividing line between two distinct formations; or they may displace a stratum of vegetable matter buried in the earth.

The observed facts teach us that heat is not requisite to the formation of ore bodies, not even enough to impair the texture of vegetable fiber or to decarbonize the thigh bone

of a buffalo. They also teach that though ore bodies are found occupying rocks undisturbed by volcanic action since the Silurian Era, they have nevertheless been formed since the appearance of mammals and dycotyladons. The inference is that the causes which formed them are acting in full force throughout the earth to-day.

While it is urged that igneous forces have no direct relation to the formation of metal-bearing veins, it is not proposed to ask miners or scientists to close their eyes to evidences of internal heat. Many writers have enlarged on the relation of volcanic action to the formation of crystalline rocks. A curious effect of heat in the formation of crystals may be seen in the formation which I had the good fortune to discover on the South Fork of Kaweah River, in Tulare County, California.

Near the east line of Sec. 16, T. 18 S., of R. 29 E., just south of the deepest channel of the stream and four rods southeast of a perpendicular fall, appears an elliptical figure in the face of the smooth, water-worn granite which is in sharp contrast with its surroundings. The figure is five feet nine inches long from north to south and three feet three inches wide from east to west. It appears as if a well had been carefully chiseled in the smooth granite, and then filled with melted matter of similar material to the surrounding rock. This melted matter seems to have been compactly filled with pebbles of nearly uniform size, and about as large as apples. The material composing the three formations seems to be the same; but the great distinguishing feature is in the form of crystallization. The crystals are very large in the granite wall and also in what appears to have been the fluid matrix in which the pebbles are incased. The two are separated by a very thin casing of quartz and a coating of what appears to be black oxide of manganese. Each of the pebbles are similarly coated. The hornblende crystals in the pebbles are excessively small near the surface of the pebbles and increase in size with marked uniformity toward the center. From the peculiarities of the crystallization it may be inferred that this is what once served as a vent for

the discharge of melted matter; and that the pebbles were formed while the fluid was in motion. If this surmise is correct then future research will be able to prove that this column of pebbles may be traced downward to an indefinite depth. In this connection reference may be made to a theory that an earthquake belt betrays a weakness in the earth's crust near the margin of the principal oceans, and that no evidence of severe earthquake convulsions is to be met within the interior of continents. It is therefore suggested that persons who adopt this theory would do well to examine the region of the Black Hills in the Territory of Wyoming. Perhaps no country in the world betrays such evidence of modern convulsions of the same magnitude and force.

There may be a lack of quantity of lava formations, but Hayden has shown that at Gothic Mountain, Colorado, a deposit of trachite has been erupted and deposited to a depth of about two thousand feet over a horizontal formation of sedimentary rock. This seems to have all resulted from one eruption. Similar eruptions on a smaller scale, are numerous in the region under consideration, and some of them repose on sand of the Quartinary Age. In a general way it may be assumed that spasmodic eruptions, in the interior of the continent are few because the available supply of water is limited, and that therefore volcanic forces are continuous in action, as at Yellowstone Park. The Rev. Titus Coan has been quoted as showing that the eruptions of Kilauea, in the Hawaiian Islands, was more intense after heavy rains; and it is asserted that the same effect has been observed elsewhere. This would tend to prove that eruptions were governed by the supply of water, but would lead us away from the interior in searching for cause.

Glacial Epochs.

Doubtless volcanic action has formed dykes and fissures in all ages, has given dip to different formations, and has changed the relative levels of continents and ocean beds. To assume that the American Continent was built up out of nothing, and that it extended from a small group of mountain peaks to the south of Hudson's Bay till the whole continent was constructed, is to argue against analogy. Tearing down and building up have always been contemporaneous and compensatory. There is no evidence furnished by the composition of the different formations to show that any large quantities of carbon have been drawn from the atmosphere, in building the rocks of any age, in excess of the carbon returned to the atmosphere by decomposition. Variations of climate have occurred. Some ages have enjoyed a climate more uniform throughout the world than others, and these may all be referred to the effect of shoaling of deep seas, whereby the heat of the tropics was transferred to the polar seas. At one time the climate of any particular locality has been hotter; at another, it has been colder than now. This is the natural result of the precessional movement or the equinoxes on the earth's ecliptic, whereby a percentage of the sun's rays is thrown more upon one pole than the other for a series of centuries together, and are then gradually transferred to the other pole by presenting first one pole to the sun at perihelion, and then the other. The transfer of this percentage of heat from one pole to the other has transferred an ice-continent from one pole to the other and has by this addition to the earth's solids in this or that locality drawn the fluid ocean after it to the extent of inundating whole continental areas. The ice-continent dur-

ing the last glacial epoch, was probably five miles above the present level of the sea on the shores of Hudson's Bay. It gradually thinned out toward the equator, but covered nearly every mountain peak of New England.

As this continent of ice melted away the ocean began to assume its former level, while the great lakes were still pouring into the Ohio a stream from one hundred and fifty to two hundred feet deep. The mouth of the St. Lawrence was still closed with ice, and a similar stream was setting southward through Lakes Champlain and George into the Hudson at Troy. While this was going on the Great Basin was being deluged with sand brought down from the northern ranges of the Rocky Mountains, as the melting ice furnished power for plowing out the Colorado.

Geologists admit that there was a period of depression during the glacial epoch, but look to a preceding elevation as the means of explaining the depth of the ice—an explanation quite unnecessary in the face of the aggregated snows of ten thousand winters. Mr. Dana says:—

"The height of the river-border formations above modern flood-level often increases to the northward." Thus showing that the only extraordinary change of sea-level during the glacial epoch was caused by the weight of the ice-continent on the pole. In all this movement of the solid through the fluid portion we have to observe the rigidity of the earth's frame-work. The uniformity of increase of height of the glacial sea-border above the present levels with the increase of latitudes is very conspicuous, and was probably greatest near the magnetic pole. After most of the ice-continent had melted, and the sea had nearly resumed its level, heavy river-terraces were being formed in high latitudes, as, for instance, along the St. Lawrence.

Time is the measure of change, and if two millions of years are necessary to account for the coral reefs, which have grown up during the Quartinary Age, we see that there must have been many glacial epochs within that time. For the most part one glacier follows in the track of another, however, and thus there is an apparent continuity of effect.

In many places, however, in local glacial centers, which are always in high altitudes, and where narrow gorges were filled hundreds and, in some cases, thousands of feet deep with ice, the height to which the different glaciers rose have been distinctly marked on the walls of the cañon by moraines of different altitudes. At Mineral King, in Tulare County, California, there is evidence that the last two glacial epochs were characterized by a more moderate flow of ice than the one preceding.

The glacial flow which dredged the floor of the polar sea united with the flow deflected to the eastward by the form of the American Continent, doubtless formed the banks of Newfoundland. The theory that they are built of the sediment brought down by the two great rivers of the continent, the Amazon and Mississippi, will doubtless be exploded by scientific research.

The immense currents generated by the melting of the glaciers which with every rotation of the equinoctial points on the plane of the ecliptic, have alternated with the Arctic and Antarctic regions, have been the chief force in transporting sediment, and in conjunction with volcanic action are the two forces constantly employed by nature in restoring youth to an aged world.

The aggregate maximum depth of all the sedimentary formations from the Archian to the Tertiary, is greater than the difference in altitude between the summits of the highest mountains and the bed of the deepest oceans; and still there is no known formation, either on land or in the sea, but what may be composed of matter once embodied in sedimentary form. Volcanic action lifts the continents and the fluids tear them down. The material embodied in the American Continent shows that a continent was torn down at the north. As a sediment-bearing current enters deep still water the edge of the deposit advances at an inclination or dip of about forty degrees, and it is the confusion and lack of conformity in the bedding caused by this condition, doubtless, which has led Mr. Dana to adopt the theory of the crushing in and folding of strata in the groin of the continent. Fold-

ings do occur and are necessarily connected with volcanic upheavals. These foldings are very common among the coal-measures of the Rocky Mountains, on the head of the Platte River, in the heart of the continent. One objection to the theory that they are the result of forces acting from a great distance, is their local bearing. If it is the foot of the arc of the ocean bed crushing in the margin of the continental area, the mountain chains should uniformally mark parallel wrinkles, as it were, on the face of time. The confusion and trend of the different foldings in California alone, will show that the force was not uniformally from the ocean.

Turning then to South America we find that the Antarctic ice-continent extended even nearer the equator. The mouth of the La Platte was blocked with ice and the valleys of the Parana and the Paraguay were invaded by the sea, and glacial drift found its way even to the tributaries of the Amazon. The Brazilian Mountains then constituted an island. Doubtless a study of the eastern hemisphere would help to confirm these views. Thus we see how fully all the known facts are explained by assuming the rigid character of the earth's structure. But as has already been explained, this assumption can only be entertained by overthrowing the theory of the radiation of heat.

Caloric.

It is proposed, then, to reopen the question of the existence of caloric, and to try to establish and identify the laws which seem to govern its action.

As to what it is which causes the ultimate atoms of certain substances to repel each other, becomes and remains a mystery if there is no caloric to act as an agent in securing such a result. But to assume the existence of caloric and a fixed ration of affinity of each particular substance for it, and another fixed ratio of affinity for every combination of substances for it, will seem to explain every phenomenon in chemistry, so far as the disengaging of heat is concerned.

Let us state, then, what seems to be the law governing the action of caloric:—

Caloric is combined in least proportion with solids.

It is combined in greater proportion with fluids.

It is combined in greatest proportion with gases.

All substances assume the solid form when deprived of caloric.

All solids may be converted into fluids by being combined with a greater proportion of caloric.

All substances assume the gaseous form when combined in greatest proportion with caloric.

When a fluid combines with any substance, which destroys its affinity for caloric, both substances become solids, as water in rock crystal.

When a compound has a less affinity for caloric than the mean of the component parts, caloric is disengaged and the bulk is lessened; as, for instance, a pint of water and a pint of dry alcohol do not make a quart. The loss is represented in the heat disengaged.

Combustion is the phenomenon of the combination of several substances into a compound which has less than the intermediate affinity for caloric. The volume is thus lessened by the disengaging of caloric.

Heat is the phenomenon of charging substances with more caloric than the ratio of prime equivalents with which they combine. In other words, heat is the passage of free caloric into every substance.

Coldness is produced by the lack of caloric to supply the ratio of prime equivalents.

All bodies are expanded in the ratio with which they combine with caloric.

In the combination of oxygen and hydrogen the bulk of the caloric set free is, say, eighteen hundred times as great as the water produced. This is the means of producing the most intense heat known.

Any substance which will combine with the oxygen of water and liberate hydrogen will produce a temperature about seven hundred degrees Fahrenheit below zero.

Metallic hydrogen when liberated from the combination with oxygen in the form of hydro-oxide—water—takes up seven thousand times its bulk of caloric.

When the relation of ultimate atoms in solid substances is disturbed by mechanical means, the particles tend to surround themselves with caloric or to acquire a new ratio of affinity for that substance during the disturbance. In other words: Friction has a negative effect on the electric attraction of substances for caloric. (Probably the same may be said of chemical action.)

Light seems to have the same effect as mechanical force and hence caloric is constantly being concentrated on the surface by the sun's rays. The proof of the existence of caloric and its action may be partly supplied by these facts: The evidence that hydrogen combines with seven thousand times its bulk of caloric rests partly upon the two facts, that in the form of gas it occupies about seven thousand times as much space as when combined with oxygen in the form of water; and in passing suddenly from its combination with oxygen it takes

enough heat from surrounding space to produce a temperature, say, seven hundred degrees below zero on Fahrenheit scale.

A similar expansion of other substances produces similar results of temperature.

Artificial application of heat converts all solids into fluids and fluids into gases.

Heat expands all substances and in a manifold ratio when it converts them into gases.

The oxidizing of carbon lessens the volume of the two substances combined, and thus disengages heat; but the diminution of the aggregate bulk of the two substances when united in the form of carbonic acid gas will hardly account for all the heat disengaged, and it must be concluded that the process of combustion of carbon is not fully understood. An investigation of this process may yet involve a searching inquiry into the nature of light and the effect of its combinations, with reference to expansion.

The draft of a furnace and the ascension of smoke will be reverted to, to prove that combustion does not lessen the bulk. The formation of ammonia in the soot, and the oxidizing of the mineral substance left in the ashes, would each cause the disengaging of caloric and add levity to the flame, whereby the carbonic acid gas, though heavier than air, would be lifted from the throat of the furnace. The nitrogen gas escaping, as the result of combustion of air, is much lighter than air, and the hydrogen entering into the combination to form ammonia would disengage a still greater percentage of caloric.

We thus see that while the liberated caloric gives levity to the flame it only carries with it the lighter properties of the air and moisture consumed, aside from carbonic acid gas. Still one difficulty remains and that is to show the philosophy of the action of the fulminates and prove them consistent with the existence of caloric. In this case the liberation of the nitrogen is so sudden and experiment so dangerous that the source from whence the caloric comes has not been fully detected and observed. If our theory is correct, coldness must

be somewhere produced as the result of explosive action, the same as in rapid chemical action producing expansion. The heat observed may be from the reflex concussion which follows and not from explosion.

Radiation of Heat.

The evidence of the earth's having been a rigid mass from the time of the earliest sedimentary formations leads to the inquiry as to whether volcanoes may not be more superficial in their nature than is assumed by those who accept the theory of a melted interior.

Thermal springs generally occur near the line of junction of two formations betraying different degrees of oxidation. Volcanoes have a similar location, and these facts suggest the oxidizing process as the source and cause of volcanic action. If this is the source of such heat, then we should expect the admission of oxygen to hidden formations, by the process of mining, to result in the disengaging of heat also; and as a rule, the further we might penetrate such formation, and the more completely the action of the atmosphere had been excluded, the more rapid the oxidizing process might be expected to be. As a fact, this rule does not hold in all cases, for a change in formations may bring a change in the degree of oxidation not proportioned to depth. On the other hand, observation shows that the increase of heat is not always in that exact proportion either.

We are entitled then to assume the debatability of the question as to whether all high temperatures in the interior of the earth, are, or are not, due to the caloric disengaged by the absorption of oxygen. If the increase of temperature is proportioned to the extent to which oxygen has been excluded from formations upon which it is now permitted to act, then high temperatures in mines are explained without the aid of heat radiated from a melted interior. The high temperature required for the action of certain solvents, supposed by many geologists to have been active in filling the fissures char-

acterized by metal-bearing veins, could not have acted among the gravel deposits of Colorado without producing more evidence of the presence of heat. The galena deposits of Wisconsin are in fissures which only extend through one or two horizontal formations and contain no evidence of the action of heat. If heat was not an essential agent in the formation of mineral veins, then there is no longer necessity for assuming a former high temperature, or that the life of the earth is gradually oozing away into vacancy.

It is at war with every idea of Omnipotence to assume that intense fusion was the necessary concomitant of a beginning, or that the grandest triumphs of creative energy must gradually yield to the devouring effects of unoccupied and fathomless space. The theory of the radiation of heat into space fails to explain the origin of this agent of a beginning or the possibility of its departure. Sir Humphrey Davy must have stood appalled at the magnitude of his discovery when he saw that the rubbing of two pieces of ice together demonstrated the certainty of the ultimate overthrow of the universe, by this eternal loss of heat and death of matter. On the contrary, there are positive evidences of the stability of the universe and a rigid structure of the earth.

The diagonal strain to which the frame-work of the earth is subjected by the location of the principal mountain chains not only surpasses that of the tides a thousand-fold, and thereby proves that the earth is not fluid, but the weighting down of the two hemispheres at equal distances from the pole, and on opposite sides of the earth, causes that precessional movement of the equinoctial points upon the plane of the ecliptic, which gives rise to annual motion and seasons. A top which has a small piece of lead attached to one side, will, when in motion, serve to illustrate the manner in which the mountains of Asia and South America swing the poles of the earth around the poles of the heavens. This vibrating tendency has doubtless been modified by the wearing down of mountain chains; and by examining into the source from which came the matter which was employed by nature in continent building, it is not

impossible that we shall discover that at one time there was a sufficient vibration of the poles of the earth to bring the polar circles within the tropics.

It is to a shoaling of the Atlantic, however, that we must look for the cause of that change of climate in the Arctic Ocean, which now precludes the possibility of a vegetable life such as characterized the period of the formation of the coal-measures.

It is quite unnecessary to explain the manner in which the heat of the tropics gives rise to oceanic currents. By placing a pot of water before the fire a current will soon be observed to strike across the center of the pot to the outer margin. When the Atlantic was connected with the polar sea by a line of deep water, this warm current reaching the Arctic Ocean must have received a rotary motion to the east in consequence of the motion of a thousand miles an hour, which the earth (and sea) have at the equator. Thus a large body of warm water entering the Arctic Ocean would rush past the island of Nova Zembla with great velocity, and encircling the pole would gradually become cool and sink beneath the warm current and return again to the equator. This warm current on the margin of the frozen ocean would modify the climate of the adjacent land (for its great eastern motion would cause it to everywhere incline to the periphery of the circle, as this motion came more directly in line with the bearing of centrifugal force).

Since the deposit of the banks of Newfoundland in the trough of the Atlantic, the warm current, after striking the west coast of Europe, has mainly returned to the equator. Thus, while its modifying influence is scarcely felt in arctic regions, it serves to intensify the heat in equatorial latitudes. There is no evidence of a former high temperature in the tropical regions; and it is not till we retire from forty to seventy degrees from the equator that we begin to discover that the flora of those regions was once more tropical in its nature.

Thus, there is only about one-third of the earth's surface which presents the evidence of having once possessed a

warmer climate. Nor can it be shown that increase of temperature was not compensated for, as already shown probable, by a lower temperature at the equator. Until the reverse is proved, it is safe to assume that the mean temperature of the whole earth was always the same. If there is a wasting away of any property in the universe—no matter whether it is substance, light, heat, motion, cause or effect,—let us demonstrate that fact first, and then inquire into the direction of escape. That the climate which produced the vegetation of the coal-measure of the latitudes of 70° and 80°, was about the same in average temperature as that of Central Europe and the northern States of the United States is to-day, cannot be doubted or denied; and nearly the same condition seems to have extended throughout the whole earth. Mildness and humidity were the characteristics; and leading geologists admit that nearly the same type of vegetation extended throughout all latitudes. That this condition of climate may have extended first to one pole for a period of ten thousand years, and then have gradually swung to the other pole, as we have already seen, in consequence of the polar circles being brought within the tropics by the weight of two mountain ranges situated on the reverse side of the two poles, which, since then, have undoubtedly been torn down by the action of the elements, is very probable.

It is difficult to identify the exact period of two formations as being the same, for coal and lignites were being formed during many ages; and it is a matter of serious question as to whether the plumbagenous and carboniferous rocks are not what now remains of a system of coal-measures anterior to all of these. Lack of all these is the question as to whether many veins of iron ore do not occupy fissures in which vegetable matter was once embedded.

Dawson and Logan assert that there is no exaggeration to maintain that there is as much carbon in the Laurencian rocks as there is in equal areas of the (so-called) carboniferous formations.

No geologist will deny, at the present time, but what the amount of carbon in rocks of that age is enormous. The

term carboniferous can be applied to zones much better than to eras; but without the Carboniferous Era the igneous theory would be illy sustained.

There is one fact tending to show that the heat resulting from the sun's rays is caloric disengaged by the action of light, which we have not yet noticed, and that is this:—

Light and heat are both concentrated in the focus of a lense; but while heat is readily passed through opaque substances, we hear very little of the refraction of the rays of heat through opaque lenses.

The Earth Under the Spectroscope.

RECENT discoveries, made through the medium of the spectroscope, have seemed to lend force to the igneous theory, and have presented questions very difficult of solution.

As is well known, the spectroscope refracts all the rays of light passing through it; and each of the different colors are refracted at different angles. On leaving the spectroscope, the different rays are thus spread out like a fan. Every substance which glows with fusion, emits rays of light which are refracted at a different angle from the rays emitted by any other substances. In some substances, however, the difference in angle is so very minute that the difference of the two rays can only be determined with certainty by examining the character of border lines which segregate the different rays.

As showing the difficulties of the problem thus presented, we may notice that it has recently been claimed that what were regarded as the iron lines in the refracted light of the sun's rays present a different border from the lines of light refracted from melted iron.

Without any purpose of antagonizing, however, any of the facts apparently established by the spectroscope, it is our present purpose to inquire how far they sustain the igneous theory.

The earth is the sounding line, by which we fathom the depths and the mysteries of the universe. In contemplating the stellar heavens we can conceive of no substance, no force, no condition, which has not its representative in the earth and its surroundings. By this test we must analyze the mysteries of the spectroscope. Does it follow then that the spectroscope shows the sun to be a great globe in a state of fusion?

In answering this question let us have recourse to a few suppositions, rather extravagant in their nature, but still supposable.

Let us suppose that the wave theory, in regard to the transmission of rays of light, is philosophically correct.

Let us suppose that an ordinary thunder-storm spread over a whole hemisphere at one time, and that this hemisphere was the side opposite the sun. Let us suppose that flashes of lightning, ordinarily vivid, spread through the whole breadth of the storm, and followed each other with that rapidity of succession which characterize the vibrations of the waves of light. This condition need not disturb the slumber or snores of the ordinary granger; and yet to the causal observer, from other spheres, the earth would appear as another sun. The waves of electric light being sufficiently near each other to fill the eye, would appear continuous.

Now let us go a step further with these suppositions. Let us suppose that half the weight of the earth's atmosphere was hydrogen gas, which, from its rare levity, floated upon the more ponderous substratum of common air; and that with it floated cosmical vapors which contained all the elementary substances.

Let us suppose that some meteoric disturbance caused the thunder-storm, by breaking the smooth surface of the aerial stratum, thus facilitating the oxidizing of the hydrogen, by withdrawing oxygen from the air. The electric currents thus engendered would be brought in direct contact with cosmical vapors and would fuse them, and thus present their lines and angles to the spectroscope.

Without assuming that that condition is ever approximated by the earth's atmosphere, it is presented as being not entirely incompatible with life on the earth; and as being entirely independent of the theory of high temperature of the earth; and as explaining most of the phenomena of the sun's rays.

A few years since, the *Scientific American*, in representing the phenomena observed during a total eclipse, presented cuts illustrating a maelstrom of flame making its swoop

across the disc of the sun with that inconceivable velocity, comparable only to the electric glare.

It cannot be claimed that the character of the sun's rays are so fully understood, as to offer no field for original research. Flames sweeping back and forth thousands of miles in a few seconds, do not speak of a state of combustion with which the inhabitants of this earth are familiar, except it is from the action of electricity; and if it is, then beneath that pyrotechnic display, there may be an orb possessed of a moist and seasonable climate. The theory that the body of the orb is in a state of combustion cannot be sustained in view of the fact that dark spots are frequently seen to move about over the sun's disc.

During the fall of 1884 a phenomenally red light was seen to appear during twilight for several months together. As to what revelations the spectroscope may have made respecting the character of this light is not known at this writing. Most probably it was the vapor of a comet absorbed by the earth's atmosphere; and as its most lurid part would be at a point where the sun's rays passed horizontally through it, it follows that the densest portion of the vapor must have been eighteen or twenty miles above the earth and extending upward, perhaps fifty miles. If this theory is correct, then this light, when viewed from the moon, would have given the earth the appearance of being surrounded by a ring.

In 1852 or 1853 the author wrote an article on comets, which was published in the Boston *Investigator* at the time, in which he took occasion to predict the phenomenon here referred too.

While comets obey the laws of gravitation, they, nevertheless, evince such a lack of ponderosity that the barometer could not be relied on to determine the presence of the vapors of one by the increased weight of the earth's atmosphere.

The Atomic Theory.

The atomic theory, when regarded as a philosophical mode of explaining the indestructibility of matter is an auxiliary to science. But when looked to as a means of establishing the infinitesimal character of ultimate atoms, in contradistinction to the idea that by chemical solution ultimate atoms themselves are thoroughly saturated by the properties of their affinities, then there are reasons for believing the theory a delusion and a snare.

It is claimed that two substances in which the shape of the atoms differ, may be made to occupy a smaller bulk by being mingled—the smaller atoms going to fill the interstices, between the larger ones. If this is all that takes place in mingling water and alcohol, from whence comes the heat disengaged; and if that is the phenomena of mixing hydrogen gas and oxygen gas, how comes it that the combined result is several thousand times less then either of the gases.

It is not the purpose of this work, however, to deal any further with the atomic theory, than to merely brush away the rubbish which obscures the understanding of the forces employed by nature in the formation of metal-bearing veins. Therefore, as introductory to that subject, it is proposed to present the proposition here, that all atoms in chemical combinations are saturated with their affinities; and that caloric forms the bulk of all gases, and a percentage of all fluids and of all solids near the surface of the earth.

Fossils in California.

THE vertical position of most of the strata of the Pacific Coast is what has been relied on to establish the theory of the crushing together of the earth's crust. The theory is, that lateral pressure has given to certain rocks a schistose structure independent of stratification, and that the cleavage in this case would be at right angles with the line of pressure. Now, if it can be shown that these vertical formations contain fossils, and that these fossils are all in a vertical position also, then there will be a new difficulty in the way of the crushing-in theory. It may be said that if the author denies that the slates were formed on their edge, he should show how they were lifted to their present position. It would be worse than folly, however, to cling to a known fallacy because the truth had not been revealed.

In the mining district of Mineral King, in Tulare County, California, the author had the good fortune to have pointed out to him a formation of calcareous slate, full of fossils, and like nearly all the formations of that district, reposing directly on its edge with fossils in like position. The shells were probably of a species of brachiopod. There was also the cast of the track of a worm having some resemblance to tracks observable in the Clinton sandstone. The fossils are probably referable to the Lower Silurian. Their position shows that the rock has been upturned; but it requires a very critical examination to determine which was the under side at the time of bedding. The various formations of the district are very nearly vertical as a rule; but most of the formations are sprung at the top towards the nearest cañon, or in the direction of the softest and most perishable formation. This tendency has doubtless given an overhanging position to

syenite; which forms the western wall of the district. At a depth of two thousand feet it is believed that the dip will be under the metamorphic rock at an angle of seventy degrees. A careful examination of the district revealed the fact that at one point east of Farewell Gap, on the summit of the Greenhorn branch of the Sierra Nevada Mountains, there is a small section where the dip of the strata is at an angle of forty degrees to the east; at which point it is in non-conformity to the syenitic gneiss of the eastern wall.

West of the fossil-bearing calcareous slate there is about one mile in width, or more properly, in the thickness of stratified rocks. One of these is a stratum of black slate very highly charged with carbon. Near the western margin is a dyke of crystalline lime or marble about two hundred feet wide, and traceable for four or five miles. It is believed, however, that this latter formation does not penetrate to a greater depth than from one thousand to two thousand feet. After what has been said, it will be assumed that the dip is to the east; and that the non-fossil-bearing strata along the western margin of the district are underlying and oldest. There is, therefore, the best of reasons for expecting that research will class some of the formations of this district as among the oldest of the sedimentary formations.

It would be beyond the scope and purpose of this work to dwell elaborately upon volcanic action, except so far as it relates to the question of a rigid earth; and, therefore, a hasty glance at the granite formations of that region is all that will be given.

If we should restore to the western slope of the Sierra Nevada Mountains, between latitudes 36° and 38°, the matter evidently carried away by the action of water, and readily traceable to the Tulare Valley, we should have a series of parallel syenite ridges bearing about twenty-four degrees west of north, and separated by depressions filled with metamorphic rock reposing on its edge; and bearing no evidence of folding, except where disturbed by some force acting at right angles with the trend of the mountains. In several places, both granite and basalt in a melted form have

been erupted through these slaty formations, and have spread in perfect non-conformity over the broken out-crop of the slate. In one of these slate formations, near the southern line of Fresno County, a compact deposit of water-worn pebbles is traceable for several miles. The pebbles, like the fossils of Mineral King, repose on their edges. They are composed of quartz, mica-slate, greenstone, granite, etc., etc., and are embedded in a slaty formation equally as compact as the other metamorphic rocks of the district under consideration. There are no fossils, and there is no reason for supposing that the matrix is other than azoic in age. The mica-slate pebbles in this formation are in no way different from rocks associated with the matrix. Some of these pebbles are somewhat metamorphosed, and some merge into the matrix. Some, perhaps a large portion, may have been somewhat flattened by lateral pressure, but many, particularly from mica-slate, retain their original form, and their position shows that the stratification was horizontal at the time of bedding. This gravel carries gold water-worn.

One of the places where erupted granite lays in non-conformity over broken slate, is west of Deer Cañon, in Mineral King Mining District. The author had the pleasure of pointing it out to Captain J. W. A. Wright, who made a careful examination and sent specimens to Professor Jackson of the University of California. The latter gentleman pronounced it "biotite granite." The rock is mainly white feldspar.

A casual glance taken thirty years ago, without reference to geological research, left the impression on the mind of the author, that there were bowlders embedded in the slate in the bed of Hangtown Creek, below the city of Placerville, Eldorado County, California. These slates may be of a more recent era, however, as Professor Whitney has found some of the slates of the placer mines to be of the Jaurasic and Triassic Age. Below or west of most of the formations noticed in the foregoing, there are a number of slate, granite, and diorite ridges having a bearing to the northeast. They may be more recent than any of the rocks of the same region just described; but let their age be what it may, they

show that the crushing-in process has ceased in this latitude, if it ever had a beginning.

Probably most of the formations of California will never reveal fossils. There is a formation at Columbia, in Tuolumne County, which, so far as explorations of miners have gone, seems to be in non-conformity to the granular limestone of that region, and to possibly rest upon it. The formation is always in disorder and in decomposition at the point of contact. This latter formation is a soft talcose slate, highly ferruginous. It is probably of the Triassic Age, but has never yielded fossils. It has the vertical position of most of the California slates, and trend also; but then there is no question but that the carbonate of lime has complete conformity to all the older slates of the region.

Trends and Reliefs.

THE mania for systematizing in science can be well illustrated by what is laid down as a system of trends and reliefs in the bearing of the island groups and mountain chains of the world. Some geologists have gone so far as to show that the mien of the general trend of the leading island groups is about 52° west of north. Now let us suppose that a line should be extended with that bearing. A spiral line would be described which would encircle the pole and approach it very rapidly during the first few revolutions but never reach it. A line continued in accordance with this cork-screw mode of reasoning could never be carried around the earth. If the reader will take an artificial globe and lay a thread on the imaginary line dividing the continental and oceanic hemispheres, it will be found, that in going directly around the globe, it at one point turns due east, at another due west, and that its relation to the pole changes at every point. A system which accepts Europe as a part of an ocean, so far as Africa is concerned, in order to make the mountain system of the latter harmonize with the supposed relation of the high mountain ranges and broad oceans of the world, should be able to harmonize anything. The same facile reasoning would have the low range of the Altai Mountains, in central Asia to represent the broad expanse of the frozen ocean, and all for the simple reason that there are no mountains or even high table-lands in Northern Asia, and without borrowing a mountain range to order, the rule would be at fault.

Turning to the eastern shore of South America, we find the coast bending to the west just south of the equator, and pursuing a general southwest course thence to the region of Cape Horn. Looking from this coast directly seaward we

find that we pass to the south of the Cape of Good Hope and that the first land we encounter is the continent of Australia. According to the rule then, the highest mountains of the world should stand on the eastern shore of South America near the Tropic of Capricorn. The truth is that the mountains of Brazil are scarcely worthy of the name of mountain, when taken in connection with the great scheme of world making.

If we reckon as mountain the number of cubic feet which stand elevated above the level of the sea, we shall find that the bulk of North America faces the frozen ocean. The table-lands all rise toward the north, all the great rivers rise there and its highest mountains are near the Arctic Circle.

An arbitrary rule has thus been laid down in regard to the configuration of continents which cannot be properly applied to either Europe, Asia, Africa, North America, or South America; while Australia is but an island anyhow, facing all the larger oceans and at the same time probably being no more remarkable for its high coast borders, than the island of New Guinea. Let the reader contrast Europe with Australia and remember that in order to apply this theory Europe is not only reckoned a part of the sea, but the South Pacific, as far out as New Zealand on the one side, and New Guinea on the other, is reckoned a part of the Australian continental area. We thus have a continent taken to give contour to the sea and a sea taken to give contour to a continent.

Under the head of "Continent-Making" we have examined into the observed phenomena, keeping steadily in view the great fact that this theory of trends and reliefs confessedly fails to give any hint of an explanation why the continents should all be grouped in one hemisphere; or to explain how such a fact could be reconciled with the theory of a fluid earth.

Formation of Oxides

We have seen how unsafe it is for the miner to follow arbitrary rules which were evidently laid down for no other purpose than rounding off a (so-called) science.

The interior of the earth is cold, compact, and rigid; rich ore bodies are never more than one mile below the surface, and successful mining never attains that depth. Steam does not form in the melted interior for these reasons:—

A column of lava, seventeen miles high, of a specific gravity of three times the weight of water, has a hydrostatic pressure which would reduce steam to the specific gravity of water; and it is at this point that the expansive power of steam begins. Further, it is not claimed by the most sanguine that the melted interior can be reached at any such depth. But even though water did completely saturate the whole interior of the earth, and fill every interstice, and meet melted matter; with this pressure it would endure a white heat below that point as quietly as gold or platinum. Therefore, some new agent must be found for any disturbance below a depth of seventeen miles. There is no expansion of steam below that point, for the prime constituents of water are forced into the fluid state by pressure. Compression evolves caloric and expansion absorbs it. Since this pressure has overcome the attractions of caloric for the gases, we may assume it has for the solids and fluids also; and that all substances are solids at that depth with no caloric and no cavity between atoms.

The material of the earth's surface is, by weight, about half oxygen; it follows that within the first fifteen miles of the surface the weight of the oxygen present must be equal to the pressure of from three thousand to five thou-

sand atmospheres, besides that represented in water; and water is eight-ninths oxygen.

Properties charged with oxygen in different ratios would become positive and negative to each other, and would generate currents of electricity which would circulate back and forth between the two formations.

Now, as we have seen, the great forces at work in the tearing down and building up of continents have an axial bearing nearly parallel with the poles of the earth. The oxidixing process comes with the solidifying of formations, while the deoxidizing process is the result of tearing down.

The mingling of properties results in new combinations, in prime equivalent ratios, in which oxygen and carbon are disengaged. Thus: if a sulphate be brought in contact with sea-salt there will, in most cases, be a chemical action and a new arrangement of prime equivalents. This is likely, in many cases, to liberate the oxygen. But when the new arrangement calls for more oxygen, then it must be drawn from the atmoshere or ocean by the slow process of ages.

Carbonate of lime has a chemical action on silex which is seldom taken into account, but the importance of which, from the standpoint of practical mining, can hardly be overrated.

In the placer mines of Tuolumne County, California, there once stood a city called Columbia. Politicians were accustomed, in addressing the miners of that locality, to speak of this little city as the "The Gem of the Southern Mines." The region for some distance in every direction is of a carbonate of lime formation, through which no gold-bearing quartz runs; and all the gold found was in washed gravel, underlying, in many cases, a cretaceous formation of the Miocene Age. Yet, within a radius of three miles of this place, one-sixth of the placer gold of California was dug. It was not an uncommon thing to dig out an oak stump or a pine log, of varieties of timber growing in California to-day, and which had been lodged on auriferous gravels, and buried beneath fifty feet of sediment. Where the gold found in this formation came from is a mining problem which

remains unsolved; and efforts of the scientific to point out the source from whence it came have only prompted the miner to disastrous experiments. The Stanislaus River has plowed out its channel since the date of this deposit, and now courses between granite bluffs thirteen hundred feet below the level of the bed of the stream which brought Columbia her gold. The drainage caused by this cutting down through this lime formation resulted in several calcareous springs on the bluffs of this river known as Gold Springs. Large bodies of travertine have been deposited by these springs, overhanging the bluff, as it were, and extending nearly to the present level of the river. And now, as showing the age of this placer gravel, it may be stated that this travertine, mainly deposited since the river had nearly reached its presnt level, has been found to overlie many of the bones of the mammoth (*mastadon maxamus*), and that in the "bed rock," where these bones were found, are impressed numerous Indian "windmills," as the miners call them; being nothing more or less than mortars where the Indian women ground their food. Two facts are thus presented. One is that the Indian with his present habits was contemporaneous with the mastodon. Another is that far beyond that, in the deep obscurity of past ages, California had a different system of rivers from what she has now; and that, even then, her climate was almost identical with her climate of to-day. It remains to be stated, however, as a fact pertinent to the inquiry, as to the effect such commingling of material may have on the oxidizing process, that they were very great. At the point of contact of lime and gravel there had been a mutual decomposition giving rise to "green clay," the toughness of which was proverbial. It was a common saying among the miners, that "that clay would roll to Stockton without washing." Thus the evidence of the departure of silex was here very marked, while further up, among the gravel, every vestige of vegetable matter was silicified.

The writer is more particular in describing this locality for the two reasons that he mined there for many years, and the country is now little else than a naked mass of lime-rock.

Other evidence might be adduced to show the action of carbonate of lime on silex. On the South Fork of the Kaweah, in Tulare County, California, granite bowlders may be found reposing against carbonate of lime with the underside, or the part resting against the lime-rock, eaten away like an old log on moist ground.

These facts lead us to the consideration of the question as to how much carbonate of lime had to do with relieving the gold dug at Columbia of the quartz with which it may be supposed to have been associated; and further, how much it may have had to do in decomposing the silex in the fissure where the gold was first deposited; or how much it may have had to do with preventing the deposit of that proportion of silex which usually forms the matrix of a gold-bearing lead.

The examination of the relation of the Columbia marbles to the gold-bearing matrix will, therefore, come up when we come to consider the law governing the formation of ore bodies.

The acting and reacting of the silicates and other substances, in this Columbia gravel deposit, upon the complicated system of fractures and cross-fractures in the marble, had wrought it into the most fantastic shapes, reaching sometimes to a depth of fifty or one hundred feet. Sometimes a large mass of the lime would be found reposing entirely on clay, and several inches of clay would have to be removed before the subjacent rock was reached on which it rested at the time the gravel was deposited. This last condition was very frequent when the disturbing forces had carried away the Miocene sediment and permitted surface moisture to penetrate. The clay and marble were always divided by a dry, meal-like coating, near a quarter of an inch thick, which would cause the clay to drop from the face of the bowlder (for such these masses of lime were called by the miners) like the discharging of a dead weight so soon as pressure was removed. This coating was from decompositon of carbonate of lime.

In treating of fossils in California, mention has been made

of another formation met with at Columbia; and one which seems to be in non-conformity to the lime, and to, perhaps, rest upon it. As has been stated, this formation is a ferruginous slate. In sinking down through this slate there are many instances where the lime bowlders have been struck and all wrought into the same fantastic shapes for fifteen or twenty feet down that has been described in connection with the placer gravel. These explorations have all been incidental, however, and have been conducted near the edge of the slate, and cannot be certainly relied on in determining the age of the formation; but their decomposition at the point of contact reveals the force of the oxidizing process.

These slate hills stand from fifty to three hundred feet above the adjacent lime, and it is a significant coincidence that the bowlders struck beneath the slate have corresponded with those of the surrounding level. It seems to hint at the idea that two or three hundred feet in depth of a gold-bearing slate of very soft texture had been wasted away by streams which probably met the ocean at a higher level.

If our geological survey had determined what the miners have here left in doubt, instead of bestowing so much untiring patience upon the wonders of the insect world, it would have come nearer meeting the expectations of a rude but practical people.

The vertical position of this slate seems fatal to the theory, however, of its being more recent than the system of California slates. It may be that the decomposition of the slate in contact with the lime, acting in conjunction with the tendency of all formations to sag toward the side receiving least lateral pressure or support, had permitted the slate to overlap the lime.

One fact might have been noticed a thousand times by any observing miner; and that was the gold dug at the point of contact between these two formations was less water-worn than that dug amongst the lime "bowlders." Further than this, there were many of the richest and most noted "pockets" found in this proximity. This fact will assume impor-

tance if we adopt the theory which will be presented further on respecting the formation of ore bodies.

Mr. Overman in his treatise on the reduction of silver ores, lays down the proposition that a paying silver lode is never found between two lime walls, but that when one of the walls is granite galena will always pay for the silver it contains. This, if correct, would lead irresistibly to the conclusion that it was the walls and not an eruptive force which gave rise to ore bodies.

Lime, though not remarkable for carrying large deposits of the precious metals, may be found to enter largely into the composition of one of the walls of many gold and silver-bearing leads. It is one of the constituents of the eastern wall of the Comstock. The dioritic porphyry of that formation being largely composed of hornblende.

In the silver mines of Colorado the presence of lime in one of the walls is generally looked upon by the miners as a prerequisite of a good mine; and this rule will apply to most of the silver mines of the State of Nevada outside of the Comstock. In view of these facts the presence of a lime formation at Columbia, where such a percentage of the placer gold of California was found, is suggestive.

In turning northward from this point, we find that a similar lime formation appears at Murphy's, in Calaveras County; at Volcanoe, in Amador County; at Indian Diggings, in El Dorado County; and that it reappears at Darlington's Ranch, three miles south of Placerville. Within five miles of the line thus indicated more than half of the placer gold of California was dug. Such facts as these should not be overlooked by those anxious to inquire as to whether the Mother Lode may or may not have given configuration to the western landscape of the Sierra Nevada Mountains. This lime follows the central trend of the great placer gold deposit of California, while the Mother Lode is below or west of it and parallel with it, and too far down the western slope to have supplied any great percentage of the gold in question.

This mineral, so frequently met with in mining regions, carries only one-half as much oxygen in proportion to the

weight of other substances as granite. This fact should not be overlooked by the scientific, in view of the circumstances of its occurrence. Oxygen, doubtless has much to do with all deposits of mineral. It is only those metals which have least affinity for oxygen that are usually found native. Silver, it is true, is often found in the form of a sulphide, owing to the strong affinity of the two substances; but any property capable of taking the sulphur from silver will reduce the latter to the metallic state. The combination of silver with oxygen is with such a slight and precarious affinity that its fulminates are the most destructive explosives known. Thus far, in considering the oxidizing process, the proposition has been accepted that water is incompressible. No satisfactory experiments have been made leading to the reverse conclusion. The experiments of Perkins did nothing more, at the furthest, than to show the elasticity of cast iron. But while we accept the proposition, we must not overlook the fact, that in the form of solids, the properties composing water are found in much smaller compass. A cubic foot of granite contains about ninety-five pounds of oxygen, while a cubic foot of water only contains about fifty-six pounds. And yet the water is eight-ninths oxygen, while the mineral substances which hold the oxygen in combination in the cubic foot of granite, weigh more than the cubic foot of water.

It is very difficult to see how this shrinkage of oxygen, in combining with solids, can be accounted for on any other theory than that something escapes. As a fact we know that heat does escape. We submit that the facts are not explained by the atomic theory; and are consistent only with the supposition that there is such a substance as caloric.

Now as a deoxidized formation takes up oxygen to give it the oxidized condition of granite, this caloric must escape no matter whether the oxygen be drawn from atmosphere or sea, except that in accordance with the theory herein laid down, the percentage of caloric in the air is many times the greatest. This caloric would manifest itself at the point where the oxidizing process was advancing, or on a line

between the oxidized and deoxidized formations. The oxygen entering the deoxidized formation would add more than one-half the bulk to the granite; and if the process continued to the depth of fifteen miles it would expand the formation sufficiently to lift the deepest bed of the ocean to the top of the highest mountain. A line of eruptive force like this would disturb and distort the metamorphic and unaltered rocks; and if two parallel upheavals of this kind occurred close together, they would leave the slate in a folded and vertical position in the valley between the two up-lifting forces; while the line of action would round off two granite ridges. One after another the granite ridges might all be formed in detail, in this manner, but could hardly be accounted for by the crushing in of the groin of the continent; for in the latter case the mountain ridges should represent nothing but the deepest formations of sedimentary rock.

We know as a fact that there is no expansion of gases among the hypogene rocks, and that it is only in those which have been erupted and have cooled near the surface that this phenomenon is presented.

This feature of a higher concentration of oxygen than that met with in the form of water, is one deserving the closest attention; for it suggests the important question as to whether water may not be decomposed by pressure. The levity of water, as compared to the other oxides is not due to the hydrogen present, for this reason; that, a study of the hydrates teaches us that hydrogen itself may become concentrated till the hydrogen present may add more than the specific gravity of water to the combination. Nor can any considerable portion of the apparent specific gravity of oxygen in other combinations be explained away by the extraordinary ponderosity of the substances with which it combines. In granite, the most important simple substance present, after oxygen, is aluminum, of which the specific gravity is about that of chalk.

From four ounces of nitrate of potash Ingenhousz is said to have obtained 3,000 cubic inches of oxygen gas. This gas

would weigh more than four cubic inches of water. The nitrogen gas present would weigh as much as one and a half cubic inches of water. This is almost incredible, however, since it does not leave the ratio of prime equivalent for the potash. The nitrate of potash was fused with a little quick lime, and a part of the oxygen may have come from that source. But while there is room for some error in the matter of the lime, it must be remembered that there was not four cubic inches of the salt analyzed. Of this about forty-six per cent by weight was potash and twelve per cent water. The water of course, was eight-ninths oxygen.

Examine the question as we may we shall find that oxygen is held in greater capacity by many other substances than by hydrogen. It may be the staple element in giving stability to the earth's frame-work. So far as we know, its combinations and affinities are only disturbed near the surface. Light changes its combinations in many instances, while the tearing down and building up of continents brings new combinations and new affinities. We have seen that the incompressibility of water is not due to the fact, as is supposed, that the hydrogen fills the intervals between ultimate atoms of oxygen; and that the space occupied by either substance will be lessened by the strength of affinity with which it combines with other substances. If the strength of affinity can be overcome by pressure, then a fluctuation of pressure resulting from the transfer of an ice-continent from one pole to the other would cause a fluctuation in the line of requisite pressure. Hydrogen and heat would be disengaged. That is to say that according to our theory the hydrogen and latent caloric pressed out would equal the shrinkage. The passage of these released elements through the earth's crust would be likely to create rents and fissures in consequence of the difference in the expansive force of caloric on different materials, and the tendency of hydrogen again to take up oxygen as soon as the diminished pressure permitted. This oxidizing of the liberated hydrogen and the attendant combustion would result in earthquake shocks; and the escaping vapors would be precipitated in the form of rain. If, how-

ever, any great amount of hydrogen gas escaped without undergoing combustion, the great amount of caloric it would absorb in its immense expansive force would be likely to chill everything with which it came in contact, and we might expect "volcanic bombs" and even bodies of ice to be ejected from the midst of melted lava.

It may be asked, if this theory is correct, that water is dissolved by pressure, and pressure is a principal agent in the production of granite, how comes the granite on the surface? To this we might answer that all the accepted theories claim that granite originates deep in the earth, and the subject of the means by which it is uncovered has been enlarged on by many writers.

If the theory is correct that ultimate atoms saturate each other, then it is clear that the only resisting force which water could offer to pressure, would be the strength of affinity of the different properties for each other. When this exact point was reached, the scale would turn. The expansion of the rock which would be occasioned by the absorption of this oxygen rendered heavier than the granite by pressure, would be sufficient to do all the crushing observed in the structure of different formations; especially since the affinity with which the substances combine is so great as to hold the oxygen in a condition three times more dense than water after the pressure is removed, and still leave granite, one of the strongest and most durable of rocks.

The doubtful factor in relation to the separate, specific gravity of oxygen in combinations, is as to the relative bulk of the hydrogen in the water. Hydrogen combines with but few substances except first in combination with oxygen in the form of water; and therefore there is but meager data from which to elucidate its most compact form. Further than this, there is such an interminable conflict of authority as to the specific gravity of hydrates, that we are left in doubt as to whether the one-ninth by weight constitutes one-third or two-thirds of the bulk of water. If it constitutes two-thirds the bulk, then the oxygen in water has nearly the specific gravity of granite. Davy and Berzelius have raised new

doubts (or have thrown new light) on the relation of oxygen and silicium. The latter of the substances, when pure, is found to be very light.

The researches of Caletet and Pictet, in 1878, showed that both oxygen and hydrogen could be reduced to the solid form by pressure, and that in no case was a pressure of more than 500 atmospheres necessary to secure this result with hydrogen. This would only be about one-seventeenth part of the pressure requisite to reduce superheated steam to the density of water, and would allow us to look for a separation of the properties of water under a much less pressure than the weight of seventeen miles of lava. Hence we are entitled to assume that it is the wonderful affinity of this substance for oxygen which prevents it from parting with all its caloric and assuming the solid form in the depths of the ocean.

Many experiments have been made with a view to the use of water as a fuel. Most of these experiments seem to have been made in disregard of the great fact that water is simply the condition of two gases after having endured combustion, and that these gases must be restored to their primitive state before combustion can be employed again. This may be done by the application of heat as well as other chemical re-agents.

If a glowing piece of charcoal be covered with hot embers, and air be then excluded by hot ashes, but little of the coal will be consumed though left buried for several days; but if a green stick be substituted for the piece of charcoal, large enough to contain the same amount of carbon, but carrying twice that amount of water, by weight, it will be found that combustion has taken place in a few hours, and that the carbon, uniting with the oxygen in the water, has disappeared in the form of carbonic acid gas.

Some of the acids have been employed, as we have already seen, in liberating hydrogen by depriving it of its oxygen when in the form of water. Any force which may be employed in separating the constituent elements of water will furnish the means of producing a fuel—the heat evolved by

combustion and the coldness produced by segregation being balancing forces. Hence, we conclude that any combustion sustained by the elements of water only represent the force employed in separating them.

Among the negative results which would be likely to follow, in case pressure deprived water of its oxygen, would be the formation of the great family of hydro-carbons, generally designated as coal oil. If the hydrogen come in contact with carbon, a chemical union would be all that would be lacking.

It will perhaps be urged that the facts cited in this volume tend to show that hydrogen is solidified with less pressure than oxygen. Caletet and Pictet employed in solidifying hydrogen less than five hundred atmospheres. Nothing is known to show that oxygen requires much more; for the combination in water may have a stronger affinity for caloric than either.

Hydro-carbon is present in all the older classes of sedimentary rocks, without reference to their relation to coal; and hydrogen has probably carried off the missing carbon in some of the Silurian and Devonian formations.

Carbon is constantly being brought up from the interior, in combination with both oxygen and hydrogen. Suppose we should reason the other way from most writers, and ask how long is this process to continue before we have a new carboniferous epoch?

The advocates of the theory of an age of carbon and of steam have overlooked two very important geological truths. One is that there is very little lack of carbon in older formations; the other is that all the older rocks are constantly sending carbon to the surface.

Reverting again to the peculiarities of deposits and formations in the placer mines, one other fact is worthy of remark, and one which I have never known to challenge anyone's attention. It is this:—

Following very nearly the central trend of the great lime-belt is a series of gravel deposits yielding gold which assays from .900 to .985; while parallel with this line, on either side

at distances of from three to five miles, are lines of gravel deposits yielding gold, assaying only .860 fine. The line of fine gold runs from Columbia to Viaceta, Volcano, Indian Diggings, and White Rock, above Placerville. The average of assays from these localities would be about .930. Let us contrast these with assays from Jimtown, Angels, Drytown, Fairplay, Shingle Springs, and Coloma. We shall find them very little above .850, and if the line ran through Salt Spring Valley, in Calaveras County, we should find them much lower. Intermediate lines would give intermediate results. While on the other side of the line, to the eastward, still lower assays can be had.

A diagram study of assays of California gold would be interesting, and fine gold would be seen to merge into the electrum or gold and silver alloy of the eastern slope.

John S. Hittell has undertaken to compile a list of assays of California gold, but has made such confusion in locating mining camps and placers as to leave his work of little value in this respect. The following locations in Tuolumne County are credited to Amador County, viz.:—

Brown's Flat, Douglass' Villa, East Columbia, (lower part of main gulch) East Columbia, (upper part of main gulch) Knapp's Ranch, Matlot Gulch, Pine Log, Bensonville, San Diego Gulch, Sawmill Flat, Springfield Flat, Three Pines, Gold Hill, and Yankee Hill. These places were the most noted mining localities in Tuolumne County, and marked the circuit of what was probably the greatest placer deposit in the known world. Again, the county seat of Amador County is included among the mining camps of Calaveras County, as also the town of El Dorado, in El Dorado County.

A correct table or diagram of assays would throw a great deal of light on the relation of the wall rock to the gold-bearing matrix. On the other hand, the character of the matrix may perhaps be determined by the character of the wall rock. A black silicate of iron, sometimes found massive between the lime formation and the adjacent slate, has probably furnished much of the gold found in the great Tuolumne placer. In this connection I will quote from Professor Hanks'

report of the State Mining Bureau in regard to the rare mineral, roscoelite.

"This very rare mineral was described in the second annual report, folio 262, and a history given of its discovery, but, as many who receive this report will not be able to refer to the former, I have thought best to insert the whole paper here:—

"'Roscoelite is a new and extremely rare mineral found in El Dorado County, California.

"'Attention was first called to it by the reading of a paper by Dr. James Blake, at a meeting of the San Francisco Microscopical Society, July 2, 1874. The specimens then exhibited were from a mine or claim, known as the "Stucksiager," "Plum Tree," or "Sam Simms" mine, which lies in Section 24, Township 11 north, and Range 9 east, Mt. Diablo base and meridian; somewhat more than a mile from the town of Coloma, in a southwest direction.

"'At a meeting of the California Academy of Sciences, held on July 20, 1874, Dr. Blake presented specimens of the same mineral, which he then supposed to be a chromium mica, having, in a preliminary examination, found as he supposed, chromic acid combined with silicia, potash, and lithium. Gold was also associated with the mineral in considerable quantities. He stated that it was found at Granite Creek, near Coloma, El Dorado County, remarking at the same time that the associated minerals were an interesting and beautiful microscopic study, and that the formation indicated that the gold must have been deposited between the flakes of the mica from an aqueous solution. He gave the new mineral the provisional name of "*Colomite*," from the locality.

"'The next notice appears in the proceedings of the California Academy of Sciences, Vol. 6, 1875, folio 150. At a meeting held August 2, of that year, Dr. Blake read a paper on "*Roscoelite*," a new mineral, in which he admitted that he had stated at a former meeting that the mineral contained a large quantity of chromic acid, an opinion derived from the results of superficial blowpipe tests. He had since sent samples to Dr. Genth, of Philadelphia, who found it to contain vanadium. He had given the name *Roscoelite* as a compli-

ment to Professor Roscoe, of Manchester, England, who has made vanadium a special study. In a foot-note, Dr. Blake expresses the opinion that vanadium may occur in these rocks in larger quantities than is generally supposed; and calls attention to the fact that Dr. Hall has found it widely diffused in many rocks.

"'The vein from which the roscoelite was taken is small and not continuous, varying from two inches to a foot in thickness, running nearly parallel with Granite Creek.

"'The quartz is ferruginous in appearance, and is associated with calcite and slaty matter, and at least two varieties of pyrites. Gold occurs only with the roscoelite, and usually in parts of the vein where the quartz disappears or "pinches out" as the miners express it.

"'Roscoelite was for a long time a mystery to the miners, and was first mistaken for plumbago. The pioneer placer miners at Big Red Ravine used to complain of the difficulty of saving the gold, owing to the interference of the "black stuff" as they designated it. In all probability, a large quantity of gold was allowed to escape from ignorance of the nature of this mineral.

"'Gold is found interstratified with laminæ of roscoelite, or embedded in it, in pieces from the value of one dollar to the minutest microscopic particles.

"'The method of operation at the mine has been to remove superficial slaty covering by ground sluicing, and carefully working the small but exceedingly rich material found in the pay-seam. From one pan of this, forty ounces of gold have been taken; from another, gold to the value of $100 was obtained. The fineness of the gold is .846.

"'Under the microscope, roscoelite is seen to be in scales and radiated tufts, the luster of which is silvery or pearly to a high degree—almost metallic by strong reflected light; color, light steel gray, yellowish, dark green, or nearly black, as seen in different lights. Small deeply striated crystals of white iron pyrites are sometimes seen in freshly broken surfaces of quartz, partly embedded. The quartz in actual contact with roscoelite is generally transparent and nearly colorless;

sometimes rose-colored or amethystine. Although rather common in the ores, pyrites have not been observed in contact with roscoelite.

"'When magnified seventy diameters, roscoelite resembles the variety of pyrophyllite found at Greaser Gulch, Mariposa County. As far as observed, the asociated gold is always bright, of good color and amorphous, generally rounded as if water-worn.

"'The other mineral associates of roscoelite are calcite and a yellow mineral, which is probably marcasite or chalcopyrite, found only in microscopic quantities.

"'The only other known locality of roscoelite in the State is in Section 31, Township 11 north, and Range 10 east, two miles from the Sam Simms mine. Big Red Ravine is on this section, lying only two miles from the site of Sutter's mill, where gold was first discovered. It was one of the earliest placer mines known in the State, and so rich did it prove, that it has paid to re-work as many as seven times. It is in the bedrock of these old workings that roscoelite is found.

"'I am indebted to Mr Geo. W. Kimble, surveyor of El Dorado County, for valuable information and for specimens of this rare and interesting mineral—with him I walked over the ground while he pointed out the localities. The largest mass found here was taken out by a Chinaman, and is described as having been as large as a gallon measure. From first to last four hundred to five hundred pounds of roscoelite have been obtained, all of which was wasted in extracting the gold.

"'I was only able to obtain for the State Museum a thin piece of quartz of a few inches superficial surface, coated on both sides with roscoelite; some large masses showing the mineral in spots, and some beautiful microscopical specimens containing gold.

"'At the Red Ravine locality, roscoelite is found in a dark colored bluish micaceous rock in small seams of quartz and calcite with gold. This rock has not yet been studied.

"'Through the politeness of Mr. James Taylor, of Owen's College, Manchester, England, I have been furnished with the following analysis of roscoelite:—

"'Analysis of roscoelite by Professor H. E. Roscoe, of Owen's College, Manchester, England—

Silica	41.25
Vanadic acid (V, 2: O, 5)	28.60
Alumina	12.84
Sesquioxide of iron	1.13
Oxide of manganese (Mn., 3; O, 4)	1.10
Lime	0.61
Magnesia	2.61
Potash	8.56
Soda	0.82
Water combined	1.08
Moisture	2.27
Total	100.27

The formation of kaolin is but a change in the form of the oxide, and the formation of the roscoelite, as elsewhere remarked, is but a replacing of a portion of the aluminum of kaolin with vanadic acid. The manner in which this action takes place, and in which the gold is combined, will be more fully considered under the head of the "Formation of Ore Bodies."

There is one evidence that the oxidizing and deoxidizing forces are about equal in nature to which we have not referred. It is this:—

The weight of the whole atmosphere would only represent enough hydrogen to answer for the decomposition of about two hundred and eighty feet of water over the whole earth. Now, as we have seen, a cubic foot of granite contains more oxygen than a cubic foot of water. There probably is not more than half that proportion of oxygen in the ocean bed, but after making every possible allowance we shall find that there is not enough hydrogen in the world to deoxidize the solid earth to the depth of five hundred feet. For, to suppose that this oxygen ever added to the aggregate of the fluids of the earth is to encounter a difficulty.

It must be assumed that all the upper regions of the atmosphere are hydrogen.

There is no evidence that even a moiety of the weight of the atmosphere is hydrogen; and none that the atmosphere

was ever heavier than it is at present. On the other hand a period of combustion must have been characterized by the oxidizing of hydrogen, or the production of water. Hence, the igneous theory would carry us back to the time when there was no water. The advocates of the igneous theory, however, instead of taking this view of the case, generally picture the budding earth as appearing beneath a cauldron of steam.

In view of the difficulties of proving the reverse, it is suggested that we accept the proposition that the mean temperature of the whole earth has always been, and will always remain, exactly the same, owing to the impossibility of the escape of any property.

If we conclude that granite underlies all other formations we shall reach the conclusion that one-half the weight of the whole earth is oxygen, without reckoning the eight-ninths of oxygen of which the ocean is composed. If the visible supply of hydrogen was sufficient we might then inquire whether all this oxygen was once in the form of water; but hydrogen is the lightest of all substances and has but a slight affinity for anything but oxygen. It is, therefore, not in its nature to sink into the earth except in the form of water. Half the atmosphere by weight, to the tops of the highest mountains, is free from it, and we search in vain for the repository of any great body of it. It has gravity and could not have escaped to the regions of space. Hence there has been no lessening of the volume of the ocean. We conclude, then, that the oxidizing and deoxidizing processes are balancing forces in perpetuity.

As a corollary to this logic, it must be concluded that the process of combustion is as rapid and general now as it ever was.

Thus, step by step, we shall reach the conclusion that the mean temperature of the whole earth, taken as a unit, is perpetually the same; and that animal and vegetable life can and does endure as high a temperature to-day as it ever did endure. Whatever the laws of evolution may have to do in changing the form of animal and vegetable life, it has nothing to do with the laws governing the status and perpe-

tuity of matter. Matter is imperishable and the laws governing it eternal.

Further than this, it is entirely too early in the day for geology to attempt to declare when it was that life first entered the world. Every organism is but an epitome of the oxidizing and deoxidizing processes going on in the material universe. Let combustion stop and life ceases. This was the law in the Silurian Age, it is the law now.

In the merging of atoms, the movement of the universe around a common center gave rise to annular and diurnal rotation, as the outstanding balance between internal and external velocities. Thus we trace the descent of this parental movement into seasons and days. It merges into winds and tides; and by tracing its effect still further we shall probably find that it is the parent of all motion, all organism, all life.

If this latter suggestion is correct then we shall be prepared to look for evidences of life coeval with the first marshaling of atoms from surrounding cosmos.

Reverting again to the fact that the older rocks are constantly sending carbon to the surface, it behooves us to inquire what force it is which produces the supply of rock oil, which for the last quarter of a century has been obtained in such abundance from the interior of the earth.

It has generally been held that artesian wells were supplied from the drainage of higher ground, as the results of gravitation. But when we shall find a well with ample flow situated on the crest of an isolated ridge, then we will begin to question as to whether an explanation of the cause of this phenomenon may be rendered so simply.

If it could be shown that the sulphur which the water generally holds in solution was in the form of a hydrate, then we might infer that there had been a decomposition of water deep down in the earth, and that the heat disengaged by the incorporation of oxygen into the rocks had been the means of forcing the water to the surface.

On the other hand, if the liberated hydrogen had come in contact with carbon instead of sulphur, the result would have

been rock oil instead of sulphureted hydrogen. The effect in either case would be to produce an artesian flow. Other combinations might give the constituents of a combustible gas.

If these surmises are correct, then oil wells, artesian wells, and wells of combustible gas, must be sought for in formations where oxygen is being absorbed; whether it is on the top of a mountain or the depression of a valley; and formations which are mainly composed of oxygen must be avoided as being no longer a source of supply for these products which result from the decomposition of water.

Combustible gas has a greater proportion of hydrogen in its composition than rock oil; and hence we should conclude that the oxidizing process disengages more carbon in the one case than in the other in proportion to the oxygen absorbed or the water decomposed.

If this reasoning is correct, then we might look for combustible gas in formations where the process of disengaging carbon has become weak or where the supply is measurably exhausted. Hence, we conclude that gas must be reached at greater depth and in regions nearer the granite.

The question would then present itself as to whether an artesian belt in alluvium where the subjacent formation was highly metamorphic was not likely to yield combustible gas without the presence of any oil-bearing formation.

Such a region would be most of the valley bordering the western base of the Sierra Nevada; while in the Coast Range, in many places an artesian flow would be supplemented by oil lower down. Still it is worthy of inquiry as to whether combustible gas may not be reached beneath all oil measures and beneath all artesian belts.

The existence of volcanoes, geysers, earthquakes, gas wells, oil wells, artesian wells and mineral springs, all speak of the decomposition of water by pressure and the absorption of oxygen in the production of granite. This process would be in harmony with the elevating of coast lines and the building up of mountain chains. The transition and sedimentary rocks, in which the forces appear, having given

up sulphur and carbon to the escaping hydrogen, would develop a new and startling affinity for a prime equivalent of the oxygen released by the decomposition of water. Absorption and expansion would thus go hand in hand until a perfect saturation with oxygen had produced the most compact and the most ponderous of rocks, and had lifted them high enough above the sea to become the base of mountain chains.

The escaping hydrogen, instead of coming directly to the surface might flow to a weaker point in the superincumbent formation and thus lift the whole like a blanket.

The so-called mud lumps at the mouth of the Mississippi afford instances of the direct escape of the hydrogen.

Step by step we thus trace volcanic forces, in their process of granite-making, along the margins of continents and other points of contact between the newer and the more highly oxidized formations. The expansive force would of course meet the greater resistance in direction of the axis of the line of action. Hence granite quarries might reveal a tendency for the rock to expand in the direction of the axis of the mountain chain. Such a phenomenon has frequently been observed. Water, then, is essential in quantity, in the contact, to produce volcanic action.

With a complete oxidizing of adjacent formations volcanic action must cease and the denuding forces must soon obliterate many evidences of its existence; and to this cause alone may be attributed the greater evidence of volcanic action in the Tertiary and Quartinary Periods.

Off the Florida Keys and along the Atlantic sea-board, sedimentary formations may be supposed to meet a pressure sufficient to produce rapid oxidation. We have no means of knowing but that the same condition exists in the southern portion of the Mississippi Valley. On the other hand the earthquake shocks experienced at New Madrid in 1811 and 1812 go far to prove the depth of the sedimentary formations in that region of the continent, while freedom from such disturbances in the region of the great lakes would tend to show that the Archian formations of the far north may dip very gradually toward the mouth of the Ohio.

It would seem, then, that in regions where sedimentary formations rise above sea level and are less than six thousand feet deep, there is likely to be immunity from earthquakes and volcanic action,—except, indeed, it be through the medium of transmitted shocks or transmitted forces.

If it should be found that hot springs, artesian oil wells, etc., could be found in a true granite formation, then this argument would fall to the ground; and the question will at once occur as to whether volcanoes continue to act in regions where the whole of the subjacent formations are in the highest state of oxidation. The effect of every oxidizing process going on in nature is to feed the current of magnetic force.

Electric Currents.

THAT the earth is a great magnet, is admitted by all electricians. Morse used two wires at first, but soon the solid earth was substituted as the medium of conveying the return current.

Currents of electricity encircle the magnet in a spiral course, and appear to move around the magnet in the direction of the hands of a watch to a person looking along the positive line of force.

The North pole is the positive pole of the magnetic earth. Hence, currents of electricity passing from the positive to the negative pole—from the north pole to the south—would move from west to east.

Currents of electricity move only upon the surface of the magnet, while the line of magnetic force is in the center.

Reference to these laws governing the action of electricity will be necessary in dealing with the next branch of our subject.

Formation of Ore Bodies.

No other question connected with the science of geology so deeply concerns the practical affairs of civilized life as does the laws governing the formation of ore bodies. No race has ever sustained a high civilization without a knowledge of the metals. With a thorough knowledge of the nature of iron and the means of reducing it, the aborigines would never have surrendered the American continent to the white man. Trace the work of the sewing machine and spindle, and contrast it with fabrics united with sinew by the use of a sharp-pointed bone, and the train of thoughts suggested will soon disclose to us the utility of a knowledge of the metals. Yet, notwithstanding the importance of knowing where to mine and how to mine, the miners of the Pacific Coast have exhausted half the aggregate energies of their lives in the endeavor to demonstrate the theory of a melted interior of the earth. Miles upon miles of tunnels have been run in the ridges of the western slope in the vain hope of tapping "the central basin." It must be remembered that the igneous theory was so comprehensive as to include the water-worn gravel deposits of the Miocene formation. River channels covered, in some instances it is true, with volcanic ash, were looked upon as an outflow of erupted matter.

At the time of the discovery of gold at Volcano, in Amador County, California, men traveled hundreds of miles to see "the volcano." Thousands returned, querying in their own minds as to how anyone knew it was a volcano. Professor Whitney speaks of this formation as "ashes and pumice stratified by water."

But to come direct to the consideration of the subject, we propose to suggest that earthquakes and volcanoes probably

have no more than an incidental relation to the formation of metal-bearing lodes. Fissures and rents do occur in the earth from volcanic action and other causes; and when so formed, even though artificial, they are liable to become the receptacles of ore deposits.

As we have already seen, currents of electricity constantly encircle the surface of the earth, running from west to east, and though theoretically spiral, yet with spirals so short as to leave the course of the currents almost exactly at right angles with the course of the magnet.

In the Daniels battery a solution of sulphate of copper is employed to take up the hydrogen disengaged by the action of acid and water on the zinc plate. The hydrogen releases the copper from the solution, and it is carried by the electric current to the copper plate and there deposited.

In the electric light, the current of electricity is made sufficiently strong to jump across an intervening space between a positive and negative carbon. In doing so, small pieces of carbon are detached and carried to the negative carbon, where they are lodged and volatilized by the concentrated heat of the obstructed current.

In electrotyping and electroplating, the electric current is made to take up a metal in solution and deposit it in a solid form.

But it is useless to instance cases in which electric currents take up metals in solution or saturating substances, and deposit them where they meet a stronger affinity or a weaker current. It is probably impossible to generate any electric current without producing more or less of these effects.

Assuming that in the prime condition of cosmical matter all ultimate atoms saturated each other we shall have the electric currents which encircle the earth coming in contact with metallic properties in the same condition they are in when held in complete chemical solution. Under these circumstances we have seen the electric currents taking them up and carrying them to where there was a break in the current such as would be caused by a fissure, or to where they came in contact with a stronger affinity. Let some of the

substances constituting their affinities be carried with them, and we have at once the metal-bearing lode. Nor need we demand volcanic heat to complete crystallization. The merest tyro in chemistry will recall a thousand and one instances in which the work of his laboratory was retarded while the cooling process was employed to encourage the formation of crystals. Here, then, we have the metal-bearing lode complete, with all its sparkling gems of crystallization, with no heat employed except that which was incidental to the action of the electric current, or the chemical action of new combinations.

Now let us go a step farther. We have seen that the oxidized and deoxidized formations had something of an axial trend, in consequence of the great sediment-bearing currents having descended from the region of the pole. These different ratios of oxidation will act upon each other and help to feed the electric currents of the earth's surface. The oxygen-seeking formations will attract the oxides while the substances which repel ogygen will remain in the metallic state or in combination with other minerals in close proximity to formations already saturated with oxygen and having no attraction therefor.

Hence, we should expect to find formations highly charged with oxygen to repose in close proximity to the western wall of veins highly charged with gold, platina, silver, or tin. Iron, with its great affinity for oxygen might be expected to be found dispersed through all the sedimentary formations. If lead should be thus dispersed it would have first to give up a large percentage of the silver with which it so readily combines, and with which it is always associated when found in highly oxidized formations.

The falling of a large body of the hanging wall of a fissure before the ore body is formed, may result in a "horse" in the lode, and at the same time give the surface outcrop all the appearance of a distorted trend, as was the case with the Comstock. In many cases bodies of the eastern wall had fallen, and had assumed electric connection with the western wall, whereby the fissure and the ore body were carried four or five hundred feet to the east.

Again, a "horse" may fill in the chasm and become a conductor, by which the metal-bearing current is carried to a companion fissure further east, as was the case in numerous instances on the Mother Lode.

In a fissure between a formation mainly composed of silex and alumina on the one side and a formation of carbonate of lime on the other, large, rough bodies of agate and chalcedony are frequently formed in lieu of quartz, though generally in shapeless masses, embedded in clay; and there are instances, even in California, in which all the various rocks characteristic of such fissures have been found to contain gold. The finding of many rich pockets of auriferous clay in such position in which the gold showed little or no evidence of being water-worn, together with the actual existence of gold in chalcedony, calcite, etc., is good evidence that it was formed in these fissures. We conclude, then, that the great body of the placer gold of California did not float up the mountain side from the Mother Lode to the lime belt, but that it was formed in close proximity to the latter.

By a careful application of the suggestions herein set forth, we shall reach the conclusion that most of the gold-bearing formations of the Pacific Slope have been torn down by the denuding power of time and the elements; and that the imperishable metal was lodged among the silts and sediments of the water-courses. We shall also learn to expect no great deposit of gold deep in the bowels of the earth if there is none on the surface. Probably very few gold leads will be found to extend one mile under ground.

Of the highly oxidized rocks the granite stands at the head—having nearly two-thirds of its composition by weight made up of oxygen. Of the great rock formations, lime combines the least oxygen, and taken as a whole, probably not more than one-third by weight is of that material. Besides this, the combined forces of the affinity of carbon for lime, and the affinity of iron and many other substances for oxygen, has doubtless expelled the sulphur from combination with calcium and other metals, thereby converting beds of gypsum into mountain limestone and metallic sul-

phurets into carbonates. This would account for sulphur springs, and would complete the circuit of that carbonic acid constantly thrown into the air and thence returned to the earth in rain-water. In facilitating this action the aluminum of the granite offers no affinity whatever for carbonic acid, while a slight affinity between silicium and carbonic acid will explain the existence of flints in the fissures of the lead mines of Wisconsin.

Contact veins running nearly at right angles with the course of the electric current, and having a large field of granite supporting the western wall, with talc, serpentine, lime, or sedimentary rocks to the eastward, are liable to be richest in gold, platina, silver, tin, and all other metals not easily oxidizable.

This law would be somewhat modified in different countries by the modified bearing of the magnetic pole. The favorable bearing would be one which slightly glanced the electric current to the south; thus causing it to traverse the walls of the lead without recoiling on its own course or conflicting with itself It will probably be found that there are but few gold-bearing leads where the trend of the fissure is east and west or parallel with the electric currents of the earth; and that these are not remarkable for richness. Furthermore, as already indicated, a good gold lead need scarcely be expected where a heavy field of feldspathic granite backs up the eastern wall with no other formation intervening. In Wisconsin, a lead lode will be found running southward along a north and south fissure for some distance, and then dropping a hundred yards to the eastward through a cross fissure will continue its course southward through a parallel fissure, while the south end of the western fissure and the north end of the eastern fissure are barren, or perhaps, "closed as tight as a miser's fist." The east and west "range" of mineral connects the mineral of the two fissures. In some of these lodes a seam of galena no thicker than a knife-blade is all that leads the miner from one ore body to another.

Doubtless the precious metals in their original cosmical condition are still, more or less, diffused through all earthy

substances, and that a trace of them may therefore be found in any and every mineral vein; but it is the mountains with a north and south trend which have yielded to commerce the great percentage of the precious metals, for instance: the Andes, Cordilleras, Rocky Mountains, Sierra Nevada, Ural, Southern Alps, Australian Alps, etc.

If we study the trend of eruptive forces as laid down by scientists we shall find them quite independent of those of metal-bearing veins. That lines of volcanic disturbances have any great tendency to observe an axial trend is not yet made clear by any observations. On the other hand, the laws governing electricity are revealed by a study of the magnet, whose unerring fidelity has conducted commerce to every clime, has brought the tribes of men into universal brotherhood, and has given a new civilization to the world.

Though it is evident that lime and gold have very little affinity, and though lime is seldom found in any proportion in a metal-bearing vein, and, perhaps, never as an electric deposit, still, it is evident that its negative character adds force to the magnetic current, and from this reasoning we deduce an explanation of the proximity of mountain limestone to the rich gold fields.

In 1886, a law was passed by Congress providing for the survey and sale of the mineral lands. The local laws, on the Pacific, generally limited miners to a claim one or two hundred feet square. The ground not actually occupied was mainly returned as abandoned mineral land, and was sold as agricultural lands. The result was that in the southern counties, in the mining district of California, placer mining nearly ceased. Enough prospecting continued in quartz, however, to develop several rich pockets in Tuolumne County. The richest of these pockets were in broken and fragmentary sheet quartz running between the lime and slate. In these cases the gold showed no evidence whatever of being water-worn, and in many cases was found adhering to, or embedded in the quartz. In the town of Sonora, a half ton of gold was taken from a shaft located within a few feet of the line of contact between the lime and the slate, and with slate

as its western wall. This pocket was far below any recent aqueous deposit, and clearly in its original position, if we except the decomposition of the quartz. The location was entirely west of the lime-belt.

At Experimental Gulch, north of Columbia, a broken ledge was found on the east side of one of the small slate ridges, heretofore spoken of, which yielded several thousand dollars. This lead was thought by many to be merely a gravel deposit. But in 1884, and after the body of this work had been written, I visited the locality, and succeeded in finding a sheet of the quartz, a rod square and a foot and a-half thick, still in place, and dipping to the east under the lime-rock—the foot wall there being called by the miners "block-ledge." From this deposit I obtained several fine specimens of gold-bearing quartz. A third quartz deposit bearing gold and similarly located is in Matlot Gulch, within the limits of the town of Columbia.

From the foregoing facts it is concluded that though Overman may be correct in his proposition that a good gold or silver ledge never occurs between two lime walls, still, a broad formation of mountain limestone in proximity, is an important factor in determining the value of a gold field.

There are a few instances where gold-bearing quartz has been found in veins having granite for the eastern wall, as in the Lewis Mine, in Tuolumne County, California, the Ella, in Calaveras County, and also at the Reward Mine at Georgetown, in El Dorado County. Still, it is doubtful whether this refers to anything more than the rock immediately in contact. As a rule the most highly oxidized rocks are at the west, and taking the adjacent formation instead of the actual contact, the rule may apply in these cases also. Writers frequently fail to discriminate between granite and greenstone, and a close inspection of these granites may show them deficient in oxygen.

Where a trap dyke is cut by a ledge of gold-bearing quartz there is likely to be found a rich pocket of gold at the intersection, but when the ledge is cut by the trap the gold will probably be found to have been transferred to a fissure

further west. Trap dykes and cross fractures thus become feeders, and their intersection with the main ledge are points famous for rich discoveries.

In the Lecompton Mine, in Nevada County, the fissure cuts both the granite and the slate without being thrown out of its course.

There is but little significance to be attached to the question of a foot or hanging wall; but the most of the gold will generally be found near the west wall. A "horse" may, however, transfer it to the body of the lode, or it may be arrested on the eastern wall by the circumstance of a better and a more continuous casing. As a rule, however, the most of the gold must be looked for on or near the western wall.

Of course there are numerous instances in which small leads have failed to conform exactly to these rules. In the White River District, in Tulare County, California, there is a system of small veins running to the north of east and having syenitic granite in both walls which carries some gold. None of these veins, however, have yielded paying rock at a depth of two hundred feet, and instances are very rare where they have been worked at a profit below a depth of twenty feet. Their dip is to the southeast at a low angle, and their pay is on the foot wall.

Several important iron mines near Rockaway, New Jersey, are similarly located, both as it respects walls and trend—the walls being granitic gneiss and their trend northeast. One of these mines, however, farther west than the others, and reposing against the base of the Copperas Mountain, has for its west wall, or at least in close proximity, a peculiar formation of hornstone porphyry which is believed to have no representative in any other part of the world. Angular crystals and fragments of quartz, feldspar, and jasper, are scattered profusely through the blue hornstone base, the whole constituting one of the hardest of known rocks, and presenting a variegated color truly beautiful.

This last-mentioned formation constitutes the backbone of the Copperas Mountain, and its highly oxidized character would lead us to expect a trace of gold and silver near the west wall of the vein.

Some of the small veins in the tin mines at Cornwall run nearly east and west, but they are very irregular and distorted and have never been traced any great distance, and we are entitled to infer the existence of a larger body of ore yet undiscovered, to which this deranged system is attached as feeders.

It could hardly occur that a fissure would run exactly parallel with the electric current of the magnetic earth. One of the walls of a long fissure must therefore intercept some of the currents. Thus in the extended fissures of the sedimentary formation many metallic oxides and sulphurets are found. In fact all the various combinations of the baser metals.

Water is a poor vehicle for the transfer of the metals of an electric current, and the probability is that most of the ore and metal deposits took place while the fissure was filled with water; and the combined action subsequent of air and water on the substances composing the walls may have resulted in decomposing the silicates in the matrix; and in releasing the native metal. This is the process employed in the production of kaolin clay. Silex and alkali decompose the granite wall by reacting on each other, and a percentage is carried away by natural leeching, leaving an excess of alumina.

If we accept a theory already understood by every manufacturer of glass, that the silicates and alkalies have a chemical action on each other, we shall expect lime and talc formations to have an action on the gold-bearing matrix as soon as exposed to the action of both air and water; and these may be the chief agents in releasing the native metal from the matrix. This wasting away is undoubtedly the chief cause which has served to conceal the fact that rich gold leads have existed in California in proximity to mountain limestone.

The gold leads of California speak of a time when the river channels were not so deep as now, and when gravel deposits spread over a large portion of the western base of the Sierra Nevada Mountains below a present altitude of four thousand feet. The indications are that these Miocene gravel

deposits are the detritus of a much heavier current than that now represented by melting snow, but the scope of this work precludes the further consideration of the forces which have given rise to excessive and long-continued currents of water.

A very large percentage of the gold which has been released from quartz and transferred to the gravel deposits is still dispersed along the eastern margin of the great valley of California, among banks of gravel too barren of the metal to render its extraction profitable. It is the first thousand feet in depth of the quartz lodes of the old placer mines, as yet unworked, which must be looked to in the coming centuries to keep the commerce of the world in motion by representing values in a universal exchange of the earth's commodities and products.

The cause of the formation of the fissures in which the ore bodies have been found is a matter that has perplexed all the geologists, inasmuch as the manner in which one fissure is thrown out by another places all the accepted theorizing at fault.

If the crust of the earth is crushing together by the shrinkage of the interior, no deep fissure should present itself on the surface. But if any force did open two fissures down to a fluid interior so that they crossed each other obliquely, it is plain that each of the parts should be thrown toward the side of the acute angle. Let a blacksmith apply a cold chisel obliquely on the edge of an iron bar and he will see this to be the effect.

But veins of ore crossing each other are thrown in the direction of the obtuse angle. This is almost an invariable rule, notwithstanding the impossibility of fitting the rule to the theory of a molten interior.

If we should suppose, however, that the interior was an unyielding solid, and that from some cause there had been a shrinkage and cracking of the surface by which broad fissures were formed, they at first, immediately after being formed, would appear as thrown toward the acute angle; but a sagging toward the side deprived of lateral support (a movement observable in all formations and very marked in

glacial action) would carry the acute angles past each other before the fissure would become filled. It would then appear as if thrown in the direction of the obtuse angle, as most veins and dykes do.

But let us suppose these forces both to be acting at the same time. The contracting force would be with the lines of radius, or away from the point of intersection, in the direction of lines running intermediate to all the fissures, while lateral pressure would be directly toward each of the fissures and diagonal to the contracting force.

Hence, a rigid earth causes veins and dykes to be thrown out in the direction of their obtuse angles.

When one of the veins is continuous it should be expected that its trend would be curved and that the acute angles of the vein thrown out should be curved outward, each in the direction of the other, and evidence of the slipping of the walls, each upon the other, should characterize both veins.

Horizontal formations, such as veins or beds of coal, are governed by the same law in the formation of faults, slips, hitches, steps, etc. They are all thrown up or down in the direction of their obtuse angles. Two fissures dipping toward each other have allowed the wedge-shaped mass to settle below the surrounding level in consequence of the shrinkage of surface formations; assuming the rigidity of the interior.

Still, we might argue from this phenomenon that the interior was everywhere and constantly expanding, and thereby producing these faults, were it not that an abundance of evidence proves the earth to be rigid.

Under the head of the "Formation of Oxides," I have treated of the silicates of iron and vanadic acid as constituting, in some cases, the gold-bearing matrix. They occur in formations of a sedimentary character where no evidence of the action of heat is betrayed. On the other hand, if we reckon the facility with which the iron and acid would enter into new combinations—thereby producing decomposition of the matrix—we shall have a new insight into the source from whence placer gold came; and shall learn that it has not been

carried so far from it original position as has been supposed. We shall also find in its occurrence in the contact between sedimentary formations new proof that it is not of volcanic origin.

We have already seen the importance of liberated hydrogen as an agent in transferring metals in solution. We have also shown, in the article on the "Formation of Oxides," how the varying pressure, due to precessional movement and consequent formation of polar glaciers, was likely to result in the liberation of hydrogen. We have only to examine the evidence adduced by earthquake shocks and volcanic eruptions, to prove that hydrogen is liberated either in this or some other manner. Some of the hydrogen liberated takes up sulphur and some carbonic acid, while some takes up only caloric; thus producing the varying temperatures of volcanoes, geysers, and ice-springs.

Whether this escaping hydrogen is a part of the machinery of that great electric battery, the earth, is open to inquiry. It suffices to note that hydrogen and electricity are both present in the battery; and that they are both active in transferring minerals and metals to new combinations.

It may be that it is the escape of hyrdogen from the metallic state to the condition of a gas which feeds the battery of the earth's magnet and gives us the phenomenon of polarity. As glacial action, the wearing down of mountains, and the expanding of rocks by the absorption of oxygen under pressure seem to be the only forces which tend to imprison and liberate hydrogen, it may be that these forces in a remote sense, are the parents of volcanoes, earthquakes, hot springs, oil wells, gas wells, artesian wells, and also metal-bearing veins.

If our theory is correct, that hydrogen and oxygen are separated by pressure, then the greatest depth to which hydrogen would be likely to penetrate the earth would be the point at which this pressure was constantly maintained. If we should conclude that the minimum pressure was one thousand atmospheres, or say thirty thousand feet, we might add to this a maximum fluctuation of coast lines at the

poles, of another thirty thousand feet, and we should have sixty thousand feet as the greatest depth to which hydrogen could reach, making no allowance for the expanding of rocks by metamorphic action, while it would be limited to thirty thousand feet near the equator. It is probable that all the convulsions that rend the earth's surface are limited to a superficial area, and that hydrogen, like electricity, only acts near the surface of the earth. Hydrogen, once separated from the combined oxygen, and imprisoned as a metal, could only be released as the result of the pressure becoming less than five hundred atmospheres. Hence, in equatorial regions, we should expect no trace of the forces which give rise to ore bodies below a depth of three miles in excess of volcanic upheavals. while they must be expected to grow weaker in the inverse ratio of the square of the depth. As a fact, no metal-bearing vein is known to penetrate the earth one mile, and when below the action of the atmosphere, all veins must be expected to grow poorer with depth.

Volcanic action may occur in the fissure and may not; but its effect in any contingency is to feed the current which carries the electric deposit to the fissure. The effect of volcanic action is therefore world-wide, whether with or without heat in the ore body. Still, as we have before observed, there is more or less heat manifest in all chemical action, or at least more or less of a change of temperature. Excessive heat may, however, interfere with the combination and the crystallization. For as we have elsewhere seen, the cooling process, is in many cases, most conducive to crystallization.

The interior of large sedimentary measures are not likely to be prolific in native metals except carried there by mechanical force; but they are likely to be rich in all the sulphurets. A trace of any or all the metals may be expected in any and every metal-bearing lead.

The net-work of gold-bearing veins at Kernville, California, will serve to illustrate the theory of electric deposit, perhaps as well as any on the Pacific Slope. This net-work is called the Big Blue; and the Sumner Mine which covers a large ex-

tent of this system has yielded about $3,000,000. These mines are situated at the eastern base of what is known as Greenhorn Mountain, being the western branch of the Sierra Nevada range. The mountain is composed of coarse syenitic granite down to near its base at Kern River. There a series of metamorphic formations set in, having in different places different characters, as diorite, porphyry, serpentine, mica-slate, gneiss, carbonate of lime, etc., etc. These metamorphic formations continue to the north for a distance of fifty or seventy-five miles; while to the west there towers this parallel accompaniment of coarse granite.

South of Kernville there is a break in the trend of the Sierra Nevada range, and it curves to the west to make a junction with the Coast Range at Tejon Pass.

The metamorphic formations bend also, and from a southeast course, further north, they now bear to the southwest. In the belly of this curve is where the Sumner Mine is located, near the contact between the granite and the altered rocks. Numerous small veins start in the granite and run, generally in a northeasterly direction, till they intercept the main ledge. These small veins have been found to carry much richer rock than the main ledge; but they were so narrow and it was necessary to remove so much waste matter in order to make room for the workmen that their working was not so profitable.

Where these small feeders entered the Big Blue a casing divided the main ledge into two compartments. What was known in the Sumner Mine as "the west vein" was almost uniform in width, having a width of three or four feet. This part of the Big Blue received these feeders and yielded the only high grade ore taken from the main ledge.

If we were to suppose electric currents to be passing through this granite in an easterly direction, we might expect them to be glanced to the south along the wall of the fissure so long as the trend was to the southeast; but when we come to where the trend was to the west of south, with small fissures coming in from the southwest, it would be necessary for the current to jump the obstruction or recoil on its own course.

We have already seen that it is under such circumstances as these that an electric current throws down its metallic burdens.

It has elsewhere been mentioned in this work that trachite was known to overlie sedimentary formations, and to the end that mining may be reduced to a science and not be conducted on the hap-hazard plan heretofore adopted, it would be well for the miners of Colorado to examine into the question as to whether an electric current passing through overhanging porphyry and trachite may not have been the agent which deposited silver among the gravel beds of that region.

If the electric current ran horizontally, of course it would not be likely to pass to an underlying formation when both formations were perfectly horizontal; but the "blanket ledges" of the regions now under consideration are not understood to be perfectly horizontal.

As we have before remarked there is no reliance to be placed in theories about the pay being next to the hanging wall. It may come from the hanging wall and it may come from the foot wall; but hanging wall or foot wall, we would prefer to trust the western wall; and particularly if the larger fields of granite or crystalline rocks lay in that direction.

We assume that the highly oxidized formations give up to the electric current more readily than any other formations do, the metals which have least affinity for oxygen. If this is a fact it may be of but little concern to the practical miner why it is so; but as every theory which is not susceptible of demonstration should be founded on reason, we will examine the question.

We have heretofore stated reasons for believing that all the solvents of gold were not yet known to science; and it may be; and it would be reasonable to suppose, that an excess of oxygen robbed of their affinities those metals having least affinity for oxygen, and thus rendered them more susceptible to the action of the electric current.

Gold has a strong affinity for both iron and sulphur; and

is generally associated with both, to some extent, in the ledge; but both of these substances have a strong affinity for oxygen, and when these properties of iron, sulphur and oxygen are united in prime equivalent proportions they are soluble in water. Hence we see how readily oxygen might become an agent in depriving the unoxidizable metals of their affinities.

There may be many scientists engaged in drawing fat salaries who will ridicule these ideas respecting the formation of ore bodies, but when they form a syndicate for the purpose of refunding the fifty million dollars squandered in the bottom of the Comstock, on the strength of their recommendations, then will the world be ready to admit that they are at least honest in their convictions.

Science has failed utterly, and most lamentably, in affording the miner any aid in determining the location of gold deposits, and this failure has done much to bring it into disrepute.

Electro-Chemical Agencies.

If we still had doubt as to the forces employed in the formation of ore bodies, we might learn a lesson from the tedious routine of experiments which have culminated in the most advanced system of amalgamating silver ores. It was formerly held that the bluestone, or magistral, as the Mexicans called this rude preparation of sulphate of copper, was put in for the purpose of supplying sulphuric acid. This was not the case; and probably sulphuric acid cannot be used without loss. On the other hand, the utility of the bluestone is to secure a double electro-chemical action and reaction of chlorides upon sulphates and sulphates upon chlorides. Hence, only such sulphates can be used as are ready to give up sulphur for chlorine. This is peculiarly the case with sulphate of copper. The soda in the saline menstruum takes the soda from a portion of the copper sulphate in exchange for the chlorine, while a portion of the chlorine is transferred to the mercury. The mercury in its turn gives up its chlorine to the silver in exchange for sulphur. Both sulphurets and oxides are thus converted into chlorides at the same time, and the silver is released in turn from its chlorine by electro-chemical action produced in the same way in which salt excites the voltaic pile. It will thus be seen that there must be enough sulphur present to disengage the requisite amount of chlorine from the salt to convert all the silver into chlorides. If any one of these agents is lacking, these combinations and exchanges cannot take place. A varying proportion of oxides and sulphurets of silver may determine the ratio of calomel and corrosive sublimate to be formed, but it is not at present seen that this would retard amalgamation, so long as there is sulphate of soda enough

formed to furnish the requisite amount of chlorine. The tendency of this subtle substance to form either muriatic acid or oxy-muriatic acids should accommodate it to the varying ratios of oxygen and sulphur in combination with the silver ores.

Since the introduction of iron in the composition of the amalgamating machinery, amalgamators have sought to prevent the precipitation of cement copper into the amalgam, as the result of the surrender of the sulphuric acid of the bluestone to the iron of the machinery, in consequence of the iron coming in contact with the menstruum, by the addition of sulphuric acid. This acid, while directly tending to reconvert the cement copper to bluestone, has indirectly the opposite effect. It removes the copper coating from the iron, and keeps it constantly exposed to the ravages of the sulphuric acid of the bluestone, and in the end aggravates the evil it was intended to remedy.

Doubtless many of the failures of mill-men, in treating ores which assayed well, have arisen from a disregard of the laws governing the forces with which nature combines and transfers metals to different affinities. Some of the failures may have arisen from the circumstance of leaving the hydro-carbon in the ore, whereby the quicksilver was coated, and floated away before chemical action had commenced. To obviate this difficulty either heat or alkali must be used first if there is any great percentage of free hydro-carbon present.

As we have already remarked, in treating of the formation of ore bodies, probably no chemical action can be employed without generating currents of electricity. We may now further remark, that probably no successful amalgamation of base ore can be performed without them. Hence, having ceased to regard the metal-bearing vein as the receptacle of a mechanical injection, it becomes a matter of prime importance to consider the prime equivalent ratios by which substances combine, as well as the relative strength of varying ratios. Thus iron combines with sulphur in two different ratios. In the one, the proportion of sulphur is, say fifty-three

per cent; in the other, less than forty. Now, let us suppose that this excess of thirteen per cent of sulphur is held by a weaker combination than that with which the forty per cent is combined, and weaker than the affinity of copper for sulphur. Under these circumstances, let us see what would take place if we should mingle bi-sulphide of iron with oxide of copper. The thirteen per cent of sulphur would then pass to the copper, if the condition was propitious, and convert the oxide of copper into sulphate, in which state it is soluble and could be leeched off into a tank, and then brought into contact with scraps of pure iron. The metallic iron of the tank would in turn draw the sulphuric acid from the copper, the iron would be dissolved, and cement copper—the purest form of the metal—would be precipitated to the bottom of the tank ready to be dried and sold. We should thus dispense with that tedious routine of eleven different smeltings employed in England, in the refining of copper, where half the copper of the world, was, until recently, produced.

Since the properties composing minerals are only found combined, chemically, in prime equivalent proportions, and in certain fixed forms of crystallization, and, since these conditions are in many cases (and presumably in all) the effect of electro-chemical action, it becomes pretty clear that igneous action had nothing to do with it. When we see the whole process carried through by mill-men in two or three hours, by the aid of steam, and by Mexicans in one summer, by the aid of the natural heat of the atmosphere and the heat engendered by chemical action, we see how leisurely nature may have worked in building up metal-bearing veins without going back even three millions of years—and the most ardent supporters of the igneous theory concede the earth to be one hundred millions of years old, and without any token of a beginning.

Instance the manner of forming an amalgam of the metal calcium with mercury. The chlorine is disengaged and the metallic calcium is amalgamated. Metallic sodium can be amalgamated with hot mercury without any other agency. Either of these amalgams would suggest themselves as an

excellent form in which to introduce the mercury in amalgamating carbonates. By such means electro-chemical action can be made to dispose of the carbon, so troublesome in many efforts at amalgamation. We must look to the manner in which nature employs re-agents. It is said these forces may be seen to-day, active in the employ of nature, in the production of various ores, at Sulphur Banks, in this State, and with a temperature below blood heat.

Thermal springs are doubtless the effect of rapid electro-chemical action, but are remote from the causes which form metal-bearing veins. The temperature of the springs at the Sulphur Bank (95°) is less than the water in the Comstock, and we have before shown that the heat of the Comstock is limited to the fissure. On the other hand the fissure is limited to the surface.

Selenium melts at a temperature of a few degrees above the boiling point, and softens at a temperature of 176° F. We are just entering a new era of gold mining, based on discoveries of gold in chemical combinations with selenium, tellurium and vanadium, and yet it certainly was not the advocates of fusion who taught us to look among these fusible and volatile substances for any deposit of the precious metals, much less to find them in chemical combination. Here lies the new El Dorado, in all probability, disguised by a present mode of assay; and when its treasures are unearthed we shall discover that electro-chemical agencies alone can explain the characteristics of elementary combinations.

To say nothing of the auriferous ores of which we, as yet, know comparatively nothing—gold is found in very close combination with ores of lead, iron, copper, antimony, mercury, tellurium, vanadium, selenium, calcium, silicium, zinc, arsenic, bismuth, baryta, fluorine, alumina, and most of their combinations.

To assume that mercury, or the still more volatile metal selenium is erupted is absurd. The same may be said of tellurium, and yet there probably is not a mine in California containing tellurium that is not chiefly valuable for its gold,

notwithstanding all its other combinations. But this is not all, gold in combination with tellurium is an ore, as much so as the combination of sulphur and lead. The time may come in which chemists will recognize the fact that gold itself combines with sulphur in a closer union than has heretofore been suspected. We talk of free gold and gold in suspension. The same expressions would sound like absurdities if applied to the ores of lead; and who is the man that can prove a less perfect combination, in certain instances, in the one case than in the other. The fact is well recognized that the combination of silver with sulphur is the same as that of lead. Nor is it safe to say, as yet, that we have discovered all the solvents of gold.

Every miner should have known long ago, that a combination of nitric and muriatic acids would dissolve gold, yet cases have presented themselves to the writer's attention, where bankers sold nitric acid purposely adulterated with muriatic acid, with the hope that they might buy in the cast-off acid for a trifle after being used in cleaning amalgam. Again many miners have been induced to follow nitric acid with salt, in cleaning gold. Of course a large amount of gold was lost in both cases. If a little *lunar caustic* had been applied to the acid in the first case mentioned the presence of the muriatic acid would at once have been both detected and removed. It is a question as to whether any great percentage of mill-men to-day understand exactly the combined effect of salt and sulphur in the treatment of gold sulphides.

Miners must learn that every solid substance constituting the earth has its chemical solvents, and that in all probability the great bulk of the precious metals are dispersed through the earth to-day, in combination with those solvents.

The conclusion we should reach, then, would be that a heavy deposit of secondary and metamorphic rocks reposing against a heavy granite formation to the west would give rise to ore bodies, hot springs, earthquakes, and all the other phenomena in which hydrogen acts a part, whether it be in combination with sulphur or carbon, as in hot springs and oil wells, or alone as in the curious production of ice beneath the earth's surface.

In the article on the "Formation of Oxides," we have quoted Prof. Hanks, of the State Mining Bureau.in regard to the occurrence of the rare mineral, roscoelite, which is found in combination with gold. It is found between slate and sandstone walls and nothing in the character or analysis to show any different origin than that of kaolin clay, found in nearly every seam or fracture of granite rock. It clearly is not the result of eruption, and the contact of the walls is necessarily and altogether superficial. The principal ingredients in the composition are, of silex, forty per cent; aluminum, fourteen per cent; and vanadic acid, twenty-eight per cent. Kaolin clay has a composition of about forty-six per cent silex; thirty-five per cent alumina; and some lime, iron, etc., as has the roscoelite. The principal difference in the chemical properties of the two minerals is that in roscoelite vanadic acid replaces a portion of the alumina. We have before remarked on the formation of kaolin.

Recurring again to the report of Prof. Hanks, he says of the divisibility of gold:—

"Mr. Cosmo Newbery, Chemist of the Geological Survey of Victoria, Australia, has made some very interesting investigations bearing on the divisibility of gold. The timber used to support the mine was assayed and in nearly every instance found to contain gold."

In a letter to the author, Prof. Hanks writes as follows:—

Mr. Stephen Barton, Lime Kiln, Tulare County, Cal.,—

Dear Sir: I am in receipt of your very interesting letter, dated September 14. I am of the opinion that gold is never mineralized in nature except during deposition of minerals in veins. Experiments made by me years ago convinced me that gold, in sylvanite and other telluric minerals, was in the metallic state, and that the so-called mineral was a mechanical mixture of tellurium and gold. I do not think that gold can escape from a skillful chemist during an assay. If you will turn to folio 386, in my last report, you will find considerable information concerning tellurium. The tellurides in the mine you mention have not been studied, but the mineral resembles altaite, telluride of lead, some of the ore is

rich, and others are almost without gold. I am pleased to obtain the information you send, as to the occurrence of gold in your county, and shall file your letter for future reference. Hoping you will excuse delay in the reply to your letter,

I remain very truly, HENRY G. HANKS,
State Mineralogist.

In the short chapter on "Electric Currents," we have endeavored to state, in concise form, the law governing the action of electricity, as understood by the most advanced electricians of the day.

In the chapter on the "Formation of Oxides," we have tried to show that it was loss of affinity which caused the more highly oxidized formations to give up their gold. Yet it must not be supposed that the degree of metamorphism is what will determine the wealth of the deposit. On the contrary the rule that time is the measure of change will apply to the growth of mineral veins, and explain why a metamorphic slate may be more productive of gold lodes than a recent granite.

We have shown by the most conclusive evidence that the "Mother Lode" was not the chief source from whence the great "placer" deposit of California gold came.

It would now be in order to examine the geology of the region adjacent to the "placer" mines, and see whether this theory has any foundation in science. We will start with Calaveras County. The Bear Mountain range is a broad belt of highly metamorphosed rock, which separates the copper regions of the foot-hills from the gold-bearing formations. Although these same formations do not appear on the landscape in other counties as a distinctive mountain chain, yet the "bed-rock" in the western margin of the placer mines will show that Calaveras is no exception to a general rule. We have also shown elsewhere that a carboniferous belt extended along or near the eastern margin of this gold-bearing region. We have also shown that a diagram of assays for fine gold—or gold more than .900 fine—would carry us directly along the trend of this carboniferous formation.

As to the more highly oxidized granites further east, their

origin probably dates back to the time when the "placer" gravel of California was being covered with "volcanic ash stratified by water," as Prof. Whitney has said. Those granites then are in many cases more recent than the gravel deposits of the Miocene river-beds.

But while dealing with the question of highly oxidized formations, we must not forget the relation which the ocean bears to the magnetic earth. Of all the oxides, hydrogen is the most highly oxidized in the form of water. Instances need not be referred to or enlarged on to prove the tendency of the solvents to carry metals and minerals to the sea. It would not, perhaps, be going beyond reasonable bounds to assume that all the elementary substances may be obtained from sea-water. Water is a good conductor of electric currents. For ages before the Miocene drift California rivers met the ocean in the region of the placer mines. Here, then, we have another reason why the carboniferous belt should be a gold-bearing formation.

The Mother Lode marks the line of a great fissure; but at an early period in the geology of the region that fissure became filled with substances having a stronger affinity for oxygen than gold; and most of the gold was carried by the electric currents of the earth to regions less metamorphosed, or at least, less oxidized.

In undertaking the study of the walls of a lode it would appear, therefore, that we must start in with a broad conception of the age and metamorphism of the whole region under consideration. It will not do to rely upon the immediate contact, for an electric connection may continue directly across the line of contact in some cases, while in others the contact determines the location of the fissure. It should be expected that an old system of trap dykes would be likely to carry the current across the line of contact; and such may have been the agencies which diffused the gold through the carboniferous region of the Columbia marbles. Under such circumstances we would have to conclude that Overman's declaration, that a paying mine of the precious metals was never to be found between two lime walls, only referred to his observa-

tions, and cannot be taken as a rule applying to the immediate contact, or, if taken as a rule, then exceptions must be allowed for all electric connections across the line of contact.

We expect that for centuries to come the carboniferous formations in the now half-abandoned gold-fields of California will betray rich "pockets" of that metal, and that it will come from "rock in place," as the law of Congress defines the gold-bearing lode. When such ore bodies are found the miner must be prepared to find new combinations. For as we have already shown, lime is unfavorable to the formation of a quartz lode. And if, as has already been surmised, there exist other solvents of gold than those now known, we must be prepared to find *ores of gold*. And why not? The whole logic of our examination tends to such a fact. When we have said that gold has no affinity for oxygen we have stated its chief distinguishing peculiarity as a metal. With all the scientific research, which seems to have ended with the conclusion reached by Prof. Hanks, that "the gold was in mechanical combination," the fact that gold tinges some ores green has not been explained, and seems inexplicable, except on the theory that the gold is in chemical combination.

The humble judgment of the author is that "mechanics," unaided by chemistry, will utterly fail in ever separating gold from all its combinations with sulphur, which result should certainly be possible, if it is only "mechanically combined." It will be noticed that there is a very wide difference in the quoted opinions of Prof. Hanks and Prof. Blake as to how the gold got into the roscoelite mentioned elsewhere. The probability is that neither one would be able to harmonize his theory with observed facts. It only shows how many different origins scientists will ascribe to the metal-bearing vein.

We see, then, that the theory of a rigid earth rises to the dignity of a question of prime importance. It is not the merits of an abstract or an abstruse science, which is alone involved, but the grandest achievements of civilized life.

Concluding Remarks.

Scientists may regard the foregoing as being too much at war with long-established theories to be accepted. It will be remembered, however, that there are many perplexing phenomena which accepted theories fail to elucidate.

Attempts have been made to show that the precessional movement of the equinoctial points upon the plane of the ecliptic, or the swinging of the poles of the earth around the circuit of the heavens was due to the attraction of the sun and moon upon the higher regions of the equator. The reasoning is too complex, and the chance for error greater than the effect accounted for. On the other hand, while it can readily be shown that both hemispheres are weighted alike, and that any bisecting of the earth into two hemispheres will cut the center of gravity, still, it cannot be shown that the two sides of either of the poles are weighted alike. The great mountain chains run diagonally around the earth. The well-known laws of mechanics and motion teach that this should produce precessional movement, and the attraction of the sun upon the equator is only consistent with the merging of that movement into itself as the attraction of the earth is with the motion of the pendulum.

True, the loss of force is not exactly proportioned to the increase of time, during which one pole is inclined to the sun during perihelion. But the reasoning of the gentleman referred to must proceed upon the theory that the inclination of the earth's axis was a condition precedent, and therefore a cause; whereas it is only an effect of precessional motion.

The attraction of the sun and moon upon the higher points of the equator are not both exactly in the same direction;

is the difference distributed with precision to all points on the equator? This of itself might and would originate a slight precessional movement if there was no conflict, but in a much shorter period. It doubtless aids to modify the extent of inclination periodically.

There is one other reason why the sun's attraction upon the equator cannot produce the swinging of the poles. There is a movement of the major axis of the earth's orbit directly in conflict with precessional motion, and in a period more than four times as long, thus distributing solar attraction.

As it relates to the evidence of former high temperature in polar regions, it cannot be shown that there ever was a higher mean temperature of the whole earth than now, or that present conditions fail to explain the change.

Enough has already been said to suggest that light and friction may both change the prime equivalent ratio of affinity of substances for caloric, and that the fact of its existence is not therefore inconsistent with the principles of chemistry, while the reduction of the elements of water to a condition of greater compactity by chemical means, when pressure will not do it while they are combined, shows that the heat disengaged by decomposition must have represented space when in latent combination.

I am not aware that any writer has undertaken to explain the throw-out of veins toward their obtuse angles on the theory of a melted interior.

The theory of a fluid earth fails to give good philosophy to the phenomena of tides in the ocean, since if the earth is a fluid mass it should yield to the same force.

The idea of folding along the margin of continents in consequence of the shrinkage of the interior of the earth does not explain the action which takes place. Upheavals occur during periods of disturbances, and subsidences follow during periods of repose.

Against the supposed case of cosmical vapors in the sun's atmosphere it may be urged that there is no cosmical vapor in the atmosphere of the earth. Well, let us see what we

have got: About two millions of miles from the earth, moving in a very eccentric orbit around the earth, in a period the same as our year, is a body of cosmical vapor known as the "zodiacal light." Saturn presents this phenomenon much nearer the body of the planet. But we are willing to concede that the revelations of the spectroscope are not understood. On the other hand, if there is any utility in the discoveries of the spectroscope, why are geologists always at fault when they touch the earth?

Metal-bearing veins do not extend below the beds of the deeper river gorges, neither at those points, nor at points intermediate "where there are high hills," as J. Ross Browne would say. Hence, veins do not continue to grow wider with depth. To recapitulate then as follows:—

1. Precessional motion arises from a diagonal weighting of polar regions.

2. A wearing down of mountain chains has lessened precessional motion, and at the same time filled in the deep sea connection with polar regions, thus changing the climate of high latitudes.

3. The prime equivalent ratio of affinity of caloric is changed by light and friction.

4. Veins are thrown in the direction of their obtuse angles as the result of a rigid interior of the earth.

5. Metal-bearing veins do not penetrate the earth one mile below the water line, nor cut below the deep river beds of California.

6. The sun's rays do not exhibit the phenomena of ordinary combustion.

7. The oldest of known rocks are sedimentary.

8. There is no evidence of a former higher temperature at the equator.

9. The phenomena of tides is based on the philosophy of a rigid earth.

10. Periods of disturbance elevate coast lines; periods of repose depress them, and therefore, the theory of folding is at fault.

11. The rule that high coast lines face the broader oceans applies best to the larger islands.

12. The trend of mountain formations is sometimes at right angles with coast lines.

13. Electric currents are the base of the magnet, and encircle the surface of the magnetic earth, running from west to east.

14. All the phenomena of the metal-bearing veins may be produced by electro-chemical action, without the aid of heat.

15. The timber used in mines becomes charged with gold by electro-chemical action.

16. Gold and roscoelite form in the contact fissures between aqueous formations.

17. The observed facts show that the crushing force met with in stone quarries is in the direction of the axis of mountain chains, and not from the sea.

Hence, we conclude that the theory of a melted interior of the earth is without foundation, and that the forces employed in forming ore bodies only act near the surface.

The geometrical ratio of the relation between the depression of the earth's poles and the breadth of the earth's sphere of attraction in the nebular hypothesis speaks of the growth and form of the earth as coming from cosmical vapor. That there may be forces in nature which disperse as well as aggregate cosmos we will not deny, but that the tendency of nature is altogether in the direction of waste and ruin we seriously question.

In the economy of nature there is nothing lost; the elements abide forever.

THE END.

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